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IF ———

IF we had perfected means of preventing even a reasonable proportion of the regular annual loss of food crops in the Philippines through the work of destructive insects and plant diseases, enough rice could be produced under present conditions to feed the people of these Islands, and to export a considerable amount. In 1924, ₱18,525,837 of Philippines money went out of the Islands for imported rice—but the legislature did not deem it expedient to give any adequate support for work in economic entomology or plant pathology.

IF we took the largest possible advantage of even the present meagre knowledge of fertilization of tropical crops, the production per unit area of all our food crops would be greatly increased.

IF we proceeded with active development of the great possibilities offered by plant breeding, the farmer would get far greater returns for his effort and ordinary cost of production.

IF we maintain an inviolate quarantine wall about Central Mindanao, the production of beef and work stock there will soon make importation unnecessary.

IF Filipinos would take a greater interest in poultry raising, the present large importation of eggs would be unnecessary.

IF Filipinos would practice thrift as do the Chinese and Japanese, the Philippines might easily possess the greatest per capita wealth of any Oriental country. The ratio of potential possibilities to population is very unusual.

IF the maximum agricultural possibilities of the Philippines are ever developed, the country will support fifty million people instead of the present eleven millions.

IF the government does not awake to the profound and fundamental importance of more active development of the sciences underlying the most successful agricultural exploitation, the rapid increase of population will only mean gradual impoverishment, and greater and greater economic difficulties.

IF the young men of the country now available could be mobilized for the development of the idle agricultural lands of the Islands there would be a rapid increase in the taxable assets of the country with a corresponding increase in revenues resulting in more efficient government—with the very important corollary of greater contentment and stability among the predominant farmer and labor class.

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A STUDY OF INHERITANCE IN TOBACCO CROSSES INVOLVING NATIVE AND IMPORTED VARIETIES¹

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The present work had for its objects the crossing of supposedly homozygous imported varieties of tobacco with native varieties, the study of quantitative inheritance of some characters, and the isolation of homozygous hybrids.

The characters studied in the present investigation are (a) age of flowering, (b) height of the plant, (c) arrangement of the leaves on the stem, and (d) number of leaves on the plant.

MATERIALS AND METHODS

This work was begun in March, 1920, and closed in March, 1923. Hybridization work was done in March, 1920, among the supposedly pure imported and native varieties of tobacco then under culture. The cultures were conducted on the acclimatization plots, which are located near the Pathology-Entomology Building of the College of Agriculture.

The F₁ generations were planted in November, 1921. All the cultures of F₁ generation were carried on on a larger scale in the Experiment Station grounds.

The varieties used in this investigation are given in table 1². The male parents are all imported while the female are all native.

TABLE 1
Varieties used and their college numbers

HYBRID NO.	MALE PARENT	COLLEGE NUMBER	GENERATION	FEMALE PARENT	COLLEGE NUMBER	GENERATION
1	Improved Gold Leaf	7808	F ₁	Repollo	9976	F ₁
2	Improved Gold Leaf	7808	F ₁	San Antonio	17099	F ₁
3	Connecticut Havana	4828	F ₁	San Juan Batec	17227	F ₁
4	Connecticut Havana	4828	F ₁	Romero	7891	F ₁
5	Improved Gold Leaf	7808	F ₁	Romero	7891	F ₁
6	Connecticut Havana	4828	F ₁	Repollo	9976	F ₁
7	Connecticut Havana	4828	F ₁	Dammao Broad Leaf	9975	F ₁

¹ Thesis presented for the degree of Master of Science in Agronomy from the University of the Philippines, No. 199, Experiment Station contribution No. 291.

² This paper includes the description of the parent plants used in hybridization and the selected hybrids from F₂ generations. The descriptions and 46 frequency curves representing the frequency distributions of parent and hybrid plants involved in the work, and 18 plates showing photographs of parent plants and selected hybrids, were not submitted for publication but are available for reference in the Department of Agronomy, College of Agriculture, Los Baños, P. I.

Most of the native varieties were obtained from Dammas Experiment Station in Isabela Province in 1918. The San Antonio was obtained in 1919 from a native farmer in the vicinity of Los Baños, Laguna. Connecticut Havana was introduced from the United States Department of Agriculture in 1918 and Improved Gold Leaf is a variety received from Richmond, Virginia, on October 29, 1917.

Just about the time the pure cultures of these plants were coming into bloom the parent plants used for hybridization work were carefully selected. Each plot of the parent plants was carefully examined several times, and the best individuals of the desired type were selected. After selecting one plant for the male parent and another for the female, hybridization of the selected varieties which are listed in table 1 was performed. The method used is that which is generally followed in tobacco hybridization.

To be certain that fertilization took place, daily examination of the treated plants and flowers was made. After the formation of the seed capsule, which is hard to the touch, and the tip of the pistil and the corolla tube had withered, the bag was removed. The cross-fertilized plants were visited frequently and all new buds trimmed off.

In making these different crosses only two flowers on each plant were treated. The rest of the flower heads were cut off from time to time.

The seeds from individual crosses were carefully harvested by cutting off the entire seed heads with the label attached to the branch; they were taken to the laboratory for drying and storage. These heads were kept separately inside the seed envelopes which were hung from the ceiling in the Seed Laboratory for drying. Later, the seeds were separated from the capsules and placed in vials where they were mixed with powdered charcoal. The corks of the containers were covered with paraffin. The seeds were put in vials daily, working one hybrid a day and using different tables. Such precaution is necessary for the tobacco seed is so small that it can be hidden under the finger nails and thus seed from one cross be easily mixed with that of another, if two or more crosses are worked on the same day.

The seeds from each distinct hybrid were sown separately. The most important points in raising experimental tobacco plants are to grow the seedlings absolutely free from contamination and to grow them and the checks under the same environmental conditions. The seeds from F_1 and parent plants were sown from September 23 to October 1, 1921. Care was taken to prevent the seeds from being carried from one culture to another, either by wind, in watering, or by the hands of the sower. The method adopted in planting the F_1 and parent plant seeds was found very satisfactory. The soil used for planting the seeds was gathered from the bank of the creek near the coffee nursery of the College, far from the tobacco fields. This was done to prevent contamination by stray tobacco seed. The soil was sterilized by heating for two hours in a galvanized iron pan, care being taken to not burn the vegetable matter.

The sterilized soil was placed in boxes made by cutting kerosene boxes lengthwise into halves. Drainage was provided by making several small holes in the bottom of the boxes.

To test the efficiency in the elimination of stray tobacco seed and of the soil sterilization method in this work, soil from the same source mixed with a few seeds

from the hybrids was sterilized in the manner described above. This soil was placed in a box, watered and cared for in exactly the same way as the soil in the boxes where the untreated seeds of the hybrids were sown. Up to the time this work was closed no seedlings of tobacco had been found in the check box.

The seeds were sown in September, 1921. Two boxes a day were sown, one in the morning and one in the afternoon, each box being labeled on the side. After sowing one box the sower washed and brushed his hands, especially his finger nails, before sowing another box. Each box was immediately taken to the Seed Laboratory after sowing and placed on the stand provided for the boxes. These were arranged far apart and covered with cheese cloth to prevent the soil in one box from accidentally getting into another. In watering the boxes care was taken to prevent mixing the seeds. The thinning of the seedlings was carried out under very close personal supervision of the writer. The student laborers who did the work were required to wash their hands after finishing each box.

The seedlings were transplanted in November, 1921. The boxes containing the seedlings were carried to the field and the young plants from one box were planted at a time. The seedlings left in each box were planted at the end of the last row, and were used four days later for replacing the plants that died. Only one replacement was carried out, other vacant hills remaining blank. These vacant places did not number more than ten in any separate culture. After transplanting, the soil in the box was thrown away and the box washed. Immediately after finishing the transplanting of the seedlings from one box, a permanent board label was placed opposite each row. Also a planting plan was made to indicate the exact location of each set of cultures in the field and the individual number of each plant. Care was taken to plant only normal seedlings.

It is to be noted that the color of the soil of the plots was very uniform and that the crop previously planted had very uniform growth. The plots, which were large enough to accommodate more than one hundred plants, were carefully prepared, levelled, and were well drained. They had been previously planted to corn. It is needless to say here that all plants which were thought to have been affected by slight local unfavorable circumstances, such as proximity to a path at each end of the field, were rejected. The plants which were studied for every character were grown in the same plot in rows. The two parent types were grown at both sides of the plot and in the center. In this manner of planting, any slight change in soil conditions from one side of the plot to the other would be indicated by the range in variation of the parent forms. The impossibility of obtaining a fairly large piece of land with uniform drainage and soil made it inadvisable to grow a large number of plants in F_1 generation. In every case effort was made to raise a large number of plants for measurements. It is well to discuss here the general methods of procedure which were employed in selecting the F_1 hybrids.

The selection of the seed plants with the greatest possible precautions to insure selfing was performed just about the time the plants were coming into bloom. Each row in the plot was examined several times and the best plant selected. At about the time the selected plant produced the first open blossoms, the blossoms, except the highest flower, of all the other plants were cut off. The highest flower was left on the plant to allow the measurement of the plant's height.

The plant was prepared for bagging at the time the first blossoms were about to open. All the leaves were trimmed off at about the point where the plant would usually be topped and all the lateral branches of the flower cluster, except a few in the very top, were removed. Any blossoms that had opened were also removed. The bags used were made of coarse white muslin (*coco*) dipped in melted paraffin and placed on a frame made of wire. As the stalk elongated, the bags were placed higher. The use of ordinary manila paper bags was found unsuitable for this work, as the bag does not allow sufficient room for the proper development of the seed and causes the top of the plant to twist and bend down. Also such bags are frequently broken by the wind before the seeds mature.

The bagged plants were examined every day. It was found that after two to four weeks the seed capsules had developed. When three to five capsules had developed, the bags were removed and the unfertilized flowers and other small buds and capsules were cut off with a pair of scissors leaving only the selected capsules.

The labeling was done at the time the seed plant was first selected by placing upon the plant a Dennison tag bearing the date of blooming of the first bud as nearly as could be judged; a tag with the date of bagging, the name and the number of the plant just treated was tied with a piece of string to the stalk just below the bag. This tag was left attached to the seed stalk when it was carried to the laboratory for drying and storage. Here the seed capsules were placed inside of a new manila paper bag to which was attached the tag from the field. The label was duplicated on one side of the paper bag before the pods were dried. There were thus two labels,—one on the paper bag and another one on the tag itself.

The F_2 seed plants were raised in exactly the same way as the F_1 seed plants. The manner in which measurements were taken is explained under the sections for the different characters studied.

The plan of culture adopted was to grow as many plants as possible in the F_1 generation to obtain a fair idea of the extent of variation as it appeared to the eye. All the plants in each plot were taken and measured. The number of the plants measured was sufficient to show whether the culture was uniform or was splitting within narrow limits. The object was to obtain as many pure intermediate homozygous forms as possible.

AGE OF FLOWERING

By "age of flowering" is meant the number of days from the date of transplanting to the date of opening of the first flower on each plant. This character was studied in Hybrid No. 2 F_2 of Improved Gold Leaf and San Antonio. The former is considered to be an early variety, while the latter is a late one. Hybrid No 4 F_2 between Connecticut Havana and Romero was also studied.

The hybrids with their parents were planted September 14, 1922. All the plants in the plots were numbered by putting a wooden label near the base of each, indicating the name, college number, and the individual number of the plant and the date of planting in the field. All the plants were examined daily, between four and six o'clock in the afternoon. The exact date when the first flower of each plant opened was recorded. It was fortunate that the weather

which prevailed during these observations was well suited to the work; the days were almost clear and such weather variations as prevailed were very slight.

The date of flowering of the parents was determined in 1922 with the F_2 generation. The parent plants and the hybrids were grown side by side and studied at the same time.

The modal type of Improved Gold Leaf flowered after 69.5 days from the date of transplanting. The modal type of the native parent, San Antonio, flowered 77.5 days after transplanting in the field. The modal type of F_2 plants flowered 77.5 days after transplanting.

There were 28.73 per cent of the Improved Gold Leaf plants which formed its modal type in the age of flowering. The proportion of the population of the native parent, San Antonio, which came under the modal class was 51.80 per cent. There were 42.04 per cent of the F_2 population in the class of greatest frequency. This showed that the greatest number of F_2 plants flowered during the time when most of the native parent plants were flowering.

The standard deviation which was determined for each parent and the F_2 plants was very much greater for F_2 plants than for the native parent but less than for the imported parent. The imported parent, Improved Gold Leaf, had a standard deviation of 10.59 ± 0.3126 days, while the native parent, San Antonio, had a standard deviation of 4.36 ± 0.2282 days. The standard deviation exhibited by the F_2 plants was 8.52 ± 0.3063 days, which was very much larger than the standard deviation exhibited by the native parent.

TABLE

Classification of Hybrid No. 2 F_2 plants according to mean age of flowering of parent varieties

MEAN OF PARENTS AND F_2 HYBRID	
Improved Gold Leaf.....	72.53 $\pm$ 0.4421 days
San Antonio.....	77.54 $\pm$ 0.3227 days
Average of parent means.....	75.03 days
Hybrid No. 2 F_2	79.84 $\pm$ 0.4331 days

F_2 CLASSIFIED INTO EARLY AND LATE GROUPS

	Early Less than 73 to 75 days	Late More than 75 days
Frequency of each group.....	33 plants	143 plants
Ratio per 4 of the groups on basis of 3:1.....	0.75	3.25
Probability ^a	5.90	

F_2 CLASSIFIED INTO EARLY, MEDIUM, AND LATE GROUPS

	Early Less than 73 days	Medium More than 72 to 78 days	Late More than 78 days
Frequency of each group.....	17 plants	72 plants	87 plants
Ratio per 16 of the groups on basis of 9:6:1.....	1.545	6.545	7.910
Probability per 100 ^b	7.3291		

^a In this and other tables when a ratio involves only two terms, "probability" means the probable occurrence of a deviation as great or greater than the designated one in 100 trials. The

greater the probability of the occurrence of the deviation, the better is the fit. Any probability equal to or more than 4.3 would mean a significant fit.

^b In this and other tables when ratio involves three or more terms, probability expresses chances that the deviation is due to error in random sampling. When the probability is 50 or more per 100, the fit is significant.

Table 2 shows the classification of the F₂ plants according to the means as shown by the parent varieties. Knowing the means of the two parent varieties, the F₂ individuals were grouped into early and late as shown in table 2. The ratio was 3.25 : 0.75. This is in accordance with the typical monohybrid ratio 3 : 1 of Mendel by a probability of 5.90 per 100. The F₂ plants were again divided into three groups, early, medium, and late. The plants observed under the three groups are also shown in table 2. Determining the ratio of segregation into these groups we find 7.910 : 6.545 : 1.545 as the actual ratio. This ratio is very close to the modified Mendelian ratio of 9 : 6 : 1. The probability being 7.3291 for every 100.

TABLE 2-A
Testing the goodness of fit of observed Hybrid 2 F₂ ratios

GROUPS	<i>Early</i>	<i>Late</i>
	Those which flowered in less than 73 to 75 days	Those which flowered in more than 75 days
Frequency of each group.....	33 plants	143 plants
Observed ratio.....	0.75	3.25
Theoretical ratio.....	1	3
Deviations.....	+0.25	-0.25
Probable error.....	± 0.088	
Deviation ÷ Probable error.....	2.8	
Probability.....	5.90	
Theoretical ratio.....	1	15
Observed ratio.....	3	13
Deviations.....	+2	-2
Probable error.....	± 0.19	
Deviation ÷ Probable error.....	10.5	
Probability.....	Very poor fit	

GROUPS	<i>Early</i>	<i>Medium</i>	<i>Late</i>
	Those which flowered in less than 73 days	Those which flowered in more than 72 to 78 days	Those which flowered in more than 78 days
Observed (o).....	17 plants	72 plants	87 plants
Expected ratio.....	1	6	9
Expected (c).....	11	66	99
o - c.....	6	6	12
(o - c) ²	36	36	144
.....	3.2727	0.5451	1.4545
^c Probability per 100.....	7.3291		

Table 2-a shows the method of testing the closeness of fit of the observed groups. The formula used for this method is the one used by Harris (1912).

In table 2-a, Probable Error = $\pm 0.6745 \sqrt{\frac{p \cdot q}{n}}$ where p and q represent the terms of the ratio and n is the total number of individuals studied. This formula is applicable only to a ratio of two terms. The actual ratio of the observed numbers under early and late groups was 3.25 : 0.75, which was compared with the monohybrid ratio of 3 : 1 and the hybrid ratio 15 : 1. It was necessary to test the goodness of fit of these ratios in order to find out which of these theoretical ratios more closely fit the observed one. When the observed ratio 3.25 : 0.75 was compared with 3 : 1 the deviation was 0.25 and the probable error was ± 0.088 . The quotient obtained by dividing the deviation by the probable error was 2.8. Comparing with the ratio 15 : 1, the quotient obtained by dividing the deviation by the probable error was 10.5. It was clear that the observed ratio fitted 3 : 1 more than it did the hybrid ratio 15 : 1. (See table 2-a.)

The F_2 plants were also grouped into three classes as shown in table 2-a.

The closeness of fit was determined according to Harris' formula, $\frac{(o - c)^2}{c} = X^2$,

in which X^2 is used in obtaining probability, o , the observed number, c , the expected number. Determining X^2 for each observed number, we find that the total for X^2 equals 5.2723. Referring to Elderton's Table I (Elderton, 1902) for testing the goodness of fit we find that 5.2723 represents a probability of 0.073291 or approximately 7 per 100. This being less than 50 per 100, it is a poor fit.

The modal age of flowering of Connecticut Havana was 65.5 days or 12 days less than the mode of the native parent, Romero. The modal age of the Hybrid No. 4 F_2 , was 65.5 days, 6 days earlier than the average of the modes of the two parent varieties. The modal age of the native parent, Romero, was 77.5 days, from the date of transplanting.

There were 26.76 per cent of the Connecticut Havana plants which fell under its modal type and only 12.50 per cent under that of Romero. The hybrid F_2 plants showed that there were 22.85 per cent which fell under the modal type of the Cross No. 4. It was observed that there were more plants of the F_2 generation which flowered after 65.5 days.

The standard deviation was determined in each parent and in F_2 plants. That for the F_2 was found to be 15.89 ± 0.7020 days. This was very much greater than the standard deviation exhibited by either parent varieties.

The coefficient of variability of the F_2 plants shows very conclusively that they were more variable than that of either of the parents. The coefficient of variability of Connecticut Havana was 17.01 ± 0.3684 per cent and that of Romero was 13.80 ± 0.5559 per cent, while that of the hybrid plants was 21.33 ± 0.9726 per cent.

TABLE 3

Classification of Hybrid No. 4 F_2 plants according to the mean age of flowering of parent varieties

MEAN OF PARENTS AND F_2 HYBRID	
Connecticut Havana.....	67.75 $\pm$ 0.4124 days
Romero.....	81.25 $\pm$ 0.5755 days
Average of parent means.....	74.5 days
Hybrid No. 4 F_2	74.5 $\pm$ 0.9928 days

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F₂ CLASSIFIED INTO EARLY AND LATE GROUPS

	<i>Early</i> Less than 68 to 75 days	<i>Late</i> More than 75 days
Frequency of each group.....	122 plants	88 plants
Ratio per 4 of the groups on basis of 3:1.....	2.324	1.676
Probability.....	Very poor fit	

F₂ CLASSIFIED INTO EARLY, MEDIUM, AND LATE GROUPS

	<i>Early</i> Less than 68 days	<i>Medium</i> More than 69 to 81 days	<i>Late</i> More than 81 days
Frequency of each group.....	113 plants	22 plants	75 plants
Ratio per 16 of the groups on basis of 9:6:1.....	8.608	1.677	5.715
Probability per 100.....		4.1932	

TABLE 3-A

Testing the goodness of fit of observed Hybrid 4 F₂ ratios

	GROUPS	
	<i>Early</i> Those which flowered in less than 68 to 75 days	<i>Late</i> Those which flowered in more than 75 days
Frequency of each group.....	122 plants	88 plants
Observed ratio.....	9.29	6.71
Theoretical ratio.....	9	7
Deviations.....	-.29	+.29
Probable error.....		+0.369
Deviation/Probable error.....		0.78
Probability.....	More than 50	Very good fit
Theoretical ratio.....	2	2
Observed ratio.....	2.32	1.68
Deviation.....	+.32	-.32
Probable error.....		+0.092
Deviation/Probable error.....		3.47
Probability.....		2.16

	GROUPS		
	<i>Early</i> Those which flowered in less than 68 days	<i>Medium</i> Those which flowered in more than 68 to 82 days	<i>Late</i> Those which flowered in more than 82 days
Observed (o).....	113 plants	22 plants	75 plants
Expected ratio.....	9	1	6
Expected (c).....	118.125	13.125	78.75
$o - c$	+5.125	-8.875	+3.75
$(o - c)^2$	26.265625	78.765625	14.0625
$(o - c)^2$	0.222	6.001	0.178
$\frac{c}{\text{Probability per 100}}$		4.1932	

Table 3 shows the classification of the F₂ plants according to the means of the two parent varieties. After determining the mean of each parent variety, the F₂ individuals were grouped into early and late classes. The actual ratio

is 2.324 : 1.676. This is in accordance with the modified dihybrid ratio of 9 : 7 of Mendel by probability of more than 50.00 per 100. (See table 3-a.) The F_2 plants were again classified into three groups as shown in table 3. The actual ratio of these groups as shown in the same table was 8.608 : 5.715 : 1.677 which does not agree with the modified dihybrid Mendelian ratio of 9 : 6 : 1. The probability being 4.1932 for every 100 trials, being less than 50 per 100.

Table 3-a shows the method of testing the goodness of fit of the observed ratios in table 3.

From the results shown in table 3-a, it is safe to say that the segregation of the F_2 plants fitted dihybrid ratio of 9 : 7 better than it did the modified monohybrid ratio of 2 : 2.

The F_2 plants were also grouped into three classes as shown in table 3-a. The value of χ^2 for the ratio 9 : 6 : 1 is 6.401. According to Elderton's Table I for testing the goodness of fit, 6.401 is equal to a probability of 0.041932, which meant that there was no reliable fit.

Hybrid Nos. 2 F_2 and 4 F_2 showed the same general results. The most interesting result was that the F_2 plants of Hybrid No. 2 resembled their native parent more than their imported parent plant in age of flowering, while Hybrid No. 4 resembled its imported more than it did the native parent. The modal group of the F_2 plants and the native parent, San Antonio, flowered after 77.5 days from the date of transplanting in the field. This cross which approached its native parent followed the Mendelian monohybrid ratio of 3 : 1, in the second generation. The modes of the imported parent, Connecticut Havana and Hybrid 4 F_2 plants, flowered after 65.5 days from the date of setting out in the field. This cross did not follow the Mendelian monohybrid ratio, 3 : 1, but segregated according to the modified dihybrid Mendelian ratio of 9 : 7.

The limits of the age of flowering of crosses Nos. 2 and 4 and those of their parents follow:

Improved Gold Leaf.....	49.5 to 105.5 days.
San Antonio.....	69.5 to 93.5 days.
Cross No. 2 F_2	49.5 to 101.5 days.
Connecticut Havana.....	41.5 to 105.5 days.
Romero.....	53.5 to 101.5 days.
Cross No. 4 F_2	53.5 to 97.5 days.

HEIGHT

All the plants used in the study of height were examined at harvest time. To give some expression of the physiological activity of the plant with regard to height, the method of determining height adopted by Howard (1913) was employed. The method is to uproot the plant and measure its height from the point where the roots begin to the apex of the stem, which in the tobacco plants ends in a capsule.

All the plants in the F_1 and F_2 generations, together with the parents, were numbered and measured. The height was determined at the same time as the number of leaves. The height was measured by means of a rod graduated to centimeters. Effort was made to make the measurements of these two important characters on the same day for each plot. No one plot was measured on two different dates.

The results from the study of inheritance of height in seven crosses are given in detail as they illustrate very well the simple expression of the most common type of quantitative inheritance.

Outline 1 presents a grouping of the F_2 plants of Cross No. 1 based on the modal heights of the two parents and F_1 plants.

OUTLINE 1.—Grouping the F_2 plants of Cross No. 1 based on the modal heights of the two parents and F_1 plants

Imported parent, Improved Gold Leaf × Native parent, Repollo
 Modal height, 120 cm. Modal height, 180 cm.
 Mean of parent modes, 150 cm.

Modal height of 98 F_1 plants, 135 cm.

Classes of 106 F_2 plants studied
 Modal height, 150 cm.

<i>Dwarf</i>	<i>Medium</i>	<i>Tall</i>
Shorter than	Shorter than	Taller than
120 to 130 cm.	135 to 160 cm.	165 cm.
32 plants	53 plants	21 plants

Ratio, 1.20 : 2.00 : 0.80

The classification of F_1 and F_2 plants of Cross No. 1 according to the modes and means of the two parent plants are given in table 4.

TABLE 4

Classification of F_1 and F_2 plants of Cross No. 1 according to the modes and means of the two parent plants

	HEIGHT	Mode	Mean
Imported parent, Improved Gold Leaf.....		120 cm.	115.4022 cm.
Native parent, Repollo.....		180 cm.	165.1886 cm.

GROUPS BASED ON MODE

	<i>Short</i> Shorter than 120 cm.	<i>Medium</i> Taller than 120 to 180 cm.	<i>Tall</i> Taller than 180 cm.
F_1 classes as related to mode.....	26 plants	72 plants	0 plants
F_1 ratio as related to mode.....	1.06	: 2.94	
F_2 classes as related to mode.....	24 plants	79 plants	3 plants
F_2 ratio as related to mode.....	0.91	: 2.98	: 0.11

GROUPS BASED ON MEAN

	<i>Short</i> Shorter than 115.4 cm.	<i>Medium</i> Taller than 115 to 165.2 cm.	<i>Tall</i> Taller than 165.2 cm.
F_1 classes as related to mean.....	72 plants	76 plants	0 plants
F_1 ratio as related to mean.....	1.95	: 2.05	
F_2 classes as related to mean.....	21 plants	70 plants	15 plants
F_2 ratio as related to mean.....	0.79	: 2.64	: 0.57

It may be assumed that the height of Improved Gold Leaf and Repollo is represented by a single factor difference; the height of the first may be represented as *aa* and of the second, *AA*. Plants of the genetic constitution *aa* then had a

mean height of 115.4022 ± 1.3614 cm., whereas plants of the genetic constitution AA averaged 165.1886 ± 1.5894 cm. It is seen from the results here presented that F_1 plants were on the average about intermediate between the two parents. The average of the means of the parents was 140.2954 cm.

The mean of the F_1 plants was 131.7857 ± 1.1610 cm. The phenotypic expression of Aa of the F_2 plants was 141.6509 ± 1.5972 cm. which was approximately equal to the average of that of the two parents, 140.2954 cm. The F_2 should consist of $1 AA : 2 Aa : 1 aa$ which has been shown to be approximately true, if the results given be accepted.

It must be understood that the only accurate method of classifying the F_2 individuals lying near the boundaries of the classes is to test them by growing the F_3 progeny of the cross. The F_2 individuals showed unimodal distribution. This did not mean that segregation failed to exist. It is very striking that practically all the values for height of the two parent varieties were represented in the F_2 generation. The F_2 plants followed the same curve as shown by the two parents. The mode and mean of these F_2 plants were higher than those of the F_1 individuals and imported parent, Improved Gold Leaf. The increase in height displayed by the F_2 individuals was probably due to heterosis.

Outline 1 shows that the modal height of the F_1 plants is about intermediate between the two modal heights of the two parent varieties. It is 15 cm. less than the average of the two modes exhibited by the parents. The F_2 plants segregated into dwarf, medium, and tall classes in the ratio 1.20 : 2.00 : 0.80. The F_2 plants were classified into dwarf and tall. All plants shorter than 120 to 130 cm. were called dwarf and those plants shorter than 135 cm. and taller than 165 cm. were called tall. There were 32 plants under dwarf and 74 plants under tall. The ratio of the tall to dwarf plants was 2.8 : 1.2 which was close to Mendel's monohybrid ratio 3 : 1, by a probability of 22.47 per 100.

Cross No. 2 was between Improved Gold Leaf and San Antonio. The two parents varied greatly in height. The modal height of Improved Gold Leaf was 120 cm. The range of variability was 30 to 210 cm. San Antonio had a mode of 195 cm., with a range of 105 to 300 cm. The modal heights in the F_1 and F_2 generations were 195 and 225 cm., respectively. The height of the F_2 plants varied from 90 to 300 cm. This cross presented an extraordinary mixture of short and tall plants. The great majority of the plants were taller than either native or imported parents. The plants were divided into three groups as shown in table 5.

TABLE 5

Classification of F_1 and F_2 plants of Cross No. 2 according to the modes and means of the two parent plants

	HEIGHT	
	Mode	Mean
Imported parent, Improved Gold Leaf.....	120 cm.	115.4022 cm.
Native parent, San Antonio.....	195 cm.	186.6867 cm.

	GROUPS BASED ON MODE		
	Short	Medium	Tall
	Shorter than 120 cm.	Taller than 120 to 195 cm.	Taller than 195 cm.
F_1 classes as related to mode.....	21 plants	46 plants	26 plants
F_1 ratio as related to mode.....	0.90	: 1.98	: 1.12
F_2 classes as related to mode.....	3 plants	37 plants	136 plants
F_2 ratio as related to mode.....	0.07	: 0.84	: 3.09

GROUPS BASED ON MEAN

	<i>Short</i> Shorter than 115.4 cm.	<i>Medium</i> Taller than 115.4 to 186.7 cm.	<i>Tall</i> Taller than 186.7 cm.
F ₁ classes as related to mean.....	20 plants	39 plants	34 plants
F ₁ ratio as related to mean.....	0.86	: 1.68	: 1.46
F ₂ classes as related to mean.....	2 plants	34 plants	140 plants
F ₂ ratio as related to mean.....	0.05	: 0.77	: 3.18

Although the F₂ did not follow the monohybrid ratio, an increase in height of the plants in F₂ generation over the F₁ and both parents was evident. The frequency distribution of the height of the parent plants and of the F₁ plants indicated uniform cultures. This fact combined with the appearance of the culture in the field and the small range of height variability showed that the parents and F₁ generation represented uniform cultures as regards height. Segregation appeared in F₂ generation. The wide range of variability in the F₂ individuals indicated that the F₂ ratio was not a simple 3 : 1. It is clear from the results in Cross No. 2 that greater vigor was produced by hybridization. The modal and mean average of the F₂ plants were greater than that of either of the parent plants or the F₁ generation.

The modal height exhibited by F₁ plants was 37.5 cm. higher than the average of the two modal heights of the two parent plants.

OUTLINE 2.—*Grouping the F₂ plants of Cross No. 2 based on the modal heights of the two parents and F₁ plants*

Imported parent, Improved Gold Leaf × *Native parent, San Antonio*

Modal height, 120 cm.

Modal height, 195 cm.

Mean of parent modes, 157.5 cm.

Modal height of 93 F₁ plants, 195 cm.

Classes of 176 F₂ plants studied

Modal height, 225 cm.

<i>Dwarf</i>	<i>Medium</i>	<i>Tall</i>
Shorter than 120 to 160 cm.	Shorter than 165 to 195 cm.	Taller than 200 cm.
18 plants	22 plants	136 plants

Ratio, 0.409 : 0.50 : 3.09

The F₂ plants with a modal height of 225 cm. segregated into three classes as shown in outline 2.

If the F₂ plants be divided into dwarf and tall plants it will be seen that there were 40 plants with a height between 120 and 195 cm. These can be classified as dwarf. There were 136 tall plants with a height taller than 200 cm. The ratio of the tall plants to the dwarf was 3.09 : 0.91. This agrees with the monohybrid ratio of 3 : 1 to a significant extent. The probability per 100 in this case was 50.00.

Cross No. 3 was between Connecticut Havana with a typical height of 180 cm., and San Juan Batec with a typical height of 240 cm. The F₁ generation

was not intermediate between the two parents. The F_2 individuals showed a typical height of 240 cm., which was 30 cm. more than the average of the two parent varieties. The F_2 plants in Cross No. 3 were divided into three groups corresponding to the typical height, and 25 plants were found as short, 115, medium, and 53, tall. The ratio was 0.52 : 2.38 : 1.10. (See table 6.)

TABLE 6

Classification of F_1 and F_2 plants of Cross No. 3 according to the modes and means of the two parent plants

	HEIGHT		
		Mode	Mean
Imported parent, Connecticut Havana.....		180 cm.	185.7464 cm.
Native parent, San Juan Batec.....		240 cm.	196.2545 cm.
GROUPS BASED ON MODE			
	Short Shorter than 180 cm.	Medium Taller than 180 to 240 cm.	Tall Taller than 240 cm.
F_1 classes as related to mode.....	96 plants	0 plants	0 plants
F_1 ratio as related to mode.....	1.00	0	0
F_2 classes as related to mode.....	25 plants	115 plants	53 plants
F_2 ratio as related to mode.....	0.52	2.38	1.10
GROUPS BASED ON MEAN			
	Short Shorter than 185.7 cm.	Medium Taller than 185.7 to 196 cm.	Tall Taller than 196 cm.
F_1 classes as related to mean.....	96 plants	0 plants	0 plants
F_1 ratio as related to mean.....	1.00	0	0
F_2 classes as related to mean.....	30 plants	10 plants	153 plants
F_2 ratio as related to mean.....	0.62	0.21	3.17

The results in Cross No. 3 need not be considered here in detail. The range of variability of the parent plants and the F_1 and F_2 plants follows:

Connecticut Havana.....	45 to 255 cm.
San Juan Batec.....	60 to 285 cm.
First generation hybrid.....	30 to 165 cm.
Second generation hybrid.....	105 to 300 cm.

The range of variability in F_2 was not greater than the ranges of the parents combined. The increased vigor in hybridization was very evident in this cross as regards average height of the parent plants and F_1 individuals compared with F_2 plants.

The F_1 plants in Cross No. 3 were very much shorter than either parent. They more closely approached the imported parent than they did the native. The F_2 plants did not follow the expected monohybrid ratio of Mendel. However, if the F_2 plants are classified into two groups, putting the dwarf and medium plants under short and those plants taller than 215 cm. under tall, the ratio of segregation will be 1.28 : 2.72 (see outline 3). There is a probability of 2.60

OUTLINE 3.—Grouping the F_2 plants of Cross No. 3 based on the modal heights of the two parents and F_1 plants

Imported parent, Connecticut Havana	×	Native parent, San Juan Batec
Modal height, 180 cm.		Modal height, 240 cm.
Mean of parent modes, 210 cm.		

Modal height of 96 F₁ plants, 45 cm.

Classes of 193 F₂ plants studied
Modal height, 240 cm.

<i>Dwarf</i>	<i>Medium</i>	<i>Tall</i>
Shorter than 45 to 115 cm.	Shorter than 120 to 210 cm.	Taller than 215 cm.
4 plants	58 plants	131 plants

Ratio, 0.08 : 1.20 : 2.72.

per 100 for this ratio to follow monohybrid ratio 3 : 1. This is a case of a poor, insignificant fit.

Cross No. 4 was between Connecticut Havana and Romero. The range of variability of the parent and the F₁ and F₂ individuals was as follows:

Connecticut Havana.....	45 to 255 cm.
Romero.....	60 to 255 cm.
First generation hybrid.....	45 to 210 cm.
Second generation hybrid.....	105 to 285 cm.

The range of variability of the F₂ was not greater than that of the parents combined. The segregation was evident, although it did not follow the monohybrid ratio. The individuals were divided into three groups, according to the modes of the two parents (see table 7). The ratio was 0.51 : 2.27 : 1.22. The

TABLE 7
Classification of F₁ and F₂ plants of Cross No. 4 according to the modes and means of the two parent plants

HEIGHT		<i>Mode</i>	<i>Mean</i>
Imported parent, Connecticut Havana.....		180 cm.	185.7464 cm.
Native parent, Romero.....		225 cm.	205.2272 cm.
GROUPS BASED ON MODE			
	<i>Short</i> Shorter than 180 cm.	<i>Medium</i> Taller than 180 to 255 cm.	<i>Tall</i> Taller than 225 cm.
F ₁ classes as related to mode.....	89 plants	3 plants	0 plants
F ₁ ratio as related to mode.....	3.87 :	1.13 :	0
F ₂ classes as related to mode.....	27 plants	119 plants	64 plants
F ₂ ratio as related to mode.....	0.51 :	2.27 :	1.22
GROUPS BASED ON MEAN			
	<i>Short</i> Shorter than 185.7 cm.	<i>Medium</i> Taller than 185.7 to 205.2 cm	<i>Tall</i> Taller than 205.2 cm.
F ₁ classes as related to mean.....	89 plants	3 plants	1 plant
F ₁ ratio as related to mean.....	3.83 :	0.13 :	0.04
F ₂ classes as related to mean.....	36 plants	40 plants	134 plants
F ₂ ratio as related to mean.....	0.69 :	0.76 :	2.55

following modal heights were found:

Connecticut Havana.....	180 cm.
Romero.....	225 cm.
First generation hybrid.....	90 cm.
Second generation hybrid.....	225 cm.

Increased height in F_2 over the imported parent was exhibited. The general results obtained in this cross were the same as those obtained in Cross No. 3. The majority of F_2 plants were found to have the same height as the native parent, Romero, if modal height of this variety is considered.

Cross No. 4 presents the same results as Cross No. 3. The F_1 plants exhibited a modal height of 90 cm. This height is only one half of that of the imported parent, Connecticut Havana.

When the F_2 plants are classified into dwarf and tall, putting plants with a height between 90 and 205 cm. under dwarf, and plants taller than 210 cm. under tall, the ratio was 1.45 : 2.55. This is in accordance with the monohybrid Mendelian ratio of 3 : 1. The probability per 100 was 0.02584 which meant a very poor fit (see outline 4).

OUTLINE 4.—Grouping the F_2 plants of Cross No. 4 based on the modal heights of the two parents and F_1 plants

Imported parent, Connecticut Havana × Native parent, Romero

Modal height, 180 cm. Modal height, 225 cm.

Mean of parent modes, 202.5 cm.

Modal height of 92 F_1 plants, 90 cm.

Classes of 210 F_2 plants studied

Modal height, 225 cm.

<i>Dwarf</i>	<i>Medium</i>	<i>Tall</i>
Shorter than	Shorter than	Taller than
90 to 135 cm.	140 to 205 cm.	210 cm.
6 plants	70 plants	134 plants

Ratio, 0.12 : 1.33 : 2.55

Cross No. 5 was between Improved Gold Leaf and Romero. The range of variability in the F_2 was greater than the range of either parent variety. The F_2 was not intermediate between the two parents. The actual modal heights in the parents, F_1 and F_2 plants were: Improved Gold Leaf, 120 cm.; Romero, 225 cm.; F_1 , 75 cm.; F_2 , 210 cm. No plant in F_1 was taller than either parent, but in F_2 there were plants taller than the tallest parent. The segregation in F_2 was greater than in either parent or in F_1 plants. The ratio obtained in F_2 when the means of the two parents were considered was 0.74 : 2.22 : 1.04 as table 8 shows.

TABLE 8

Classification of F_1 and F_2 plants of Cross No. 5 according to the modes and means of the two parent plants

	HEIGHT		
		<i>Mode</i>	<i>Mean</i>
Imported parent, Improved Gold Leaf.....		120 cm.	115.4022 cm.
Native parent, Romero.....		225 cm.	205.2272 cm.
	GROUPS BASED ON MODE		
	<i>Short</i>	<i>Medium</i>	<i>Tall</i>
	Shorter than	Taller than	Taller than
	120 cm.	120 to 225 cm.	225 cm.
F_1 classes as related to mode.....	103 plants	7 plants	0 plants
F_1 ratio as related to mode.....	3.75	: 0.25 :	0
F_2 classes as related to mode.....	51 plants	189 plants	20 plants
F_2 ratio as related to mode.....	0.78	: 2.91 :	0.31

	GROUPS BASED ON MEAN		
	<i>Short</i>	<i>Medium</i>	<i>Tall</i>
	Shorter than 115.4 cm.	Taller than 115.4 to 205 cm.	Taller than 205 cm.
F ₁ classes as related to mean.....	103 plants	7 plants	0 plants
F ₁ ratio as related to mean.....	3.74 :	0.26 :	0
F ₂ classes as related to mean.....	48 plants	144 plants	68 plants
F ₂ ratio as related to mean.....	0.74 :	2.22 :	1.04

The F₂ generation of Cross No. 5 formed a continuous series which extended beyond the limits of the parents. This cross demonstrated, as the other crosses did, that increase in height was obtained from the plants in F₁ generation.

Cross No. 5 gave F₁ plants the modal height of which was 75 cm. This approached the modal height of the imported parent.

The F₂ plants may be classified into dwarf and tall plants. Putting those plants with height between 75 and 175 cm. under dwarf, and plants taller than 180 cm. under tall, the ratio of segregation was 1.95 : 2.05. This satisfied the modified Mendelian monohybrid ratio 2 : 2, with a probability of 45.81 per 100 (see outline 5).

OUTLINE 5.—*Grouping the F₂ plants of Cross No. 5 based on the modal heights of the two parents and F₁ plants*

Imported parent, Improved Gold Leaf × *Native parent, Romero*
 Modal height, 120 cm. Modal height, 225 cm.
 Mean of parent modes, 172.5 cm.

Modal height of 110 F₁ plants, 75 cm.

Classes of 260 F₂ plants studied
 Modal height, 210 cm.

<i>Dwarf</i>	<i>Medium</i>	<i>Tall</i>
Shorter than	Shorter than	Taller than
75 to 100 cm.	105 to 175 cm.	180 cm.
32 plants	95 plants	133 plants

Ratio, 0.49 : 1.46 : 2.05.

Cross No. 6 was between Connecticut Havana and Repollo. The actual modal heights were: Connecticut Havana, 180 cm.; Repollo, 180 cm.; F₁, 135 cm.; F₂, 180 cm.

The range of variability in the parents, F₁ and F₂, was found to be as follows:

Connecticut Havana.....	45 to 255 cm.
Repollo.....	75 to 225 cm.
First generation hybrid.....	90 to 210 cm.
Second generation hybrid.....	75 to 240 cm.

The two parents did not differ very greatly in height.

The F₁ generation was intermediate between the two parent varieties. The F₂ plants exhibited a wider range of variability than the F₁ individuals.

When the means of the two parents were considered, the actual ratio of segregation was 1.23 : 1.58 : 1.19 (see table 9). The modal heights exhibited by both parents were the same, but the F₂ plants showed a marked increase.

TABLE 9

Classification of F₁ and F₂ plants of Cross No. 6 according to the modes and means of the two parent plants

	HEIGHT		<i>Mode</i>	<i>Mean</i>
Imported parent, Connecticut Havana.....			180 cm.	185.7464 cm.
Native parent, Repollo.....			180 cm.	165.1886 cm.
GROUPS BASED ON MEAN				
	<i>Short</i>	<i>Medium</i>	<i>Tall</i>	
	Shorter than	Taller than	Taller than	
	165.2 cm.	165.2 to 185.7 cm.	185.7 cm.	
F ₁ classes as related to mean.....	73 plants	7 plants	4 plants	
F ₁ ratio as related to mean.....	3.48 :	0.33 :	0.19	
F ₂ classes as related to mean.....	76 plants	97 plants	73 plants	
F ₂ ratio as related to mean.....	1.23 :	1.58 :	1.19	

Cross No. 6 gave F₁ plants with a modal height of 135 cm. The parent plants had the same modal height. The F₂ plants were classified into dwarf and tall. By dwarf is meant in this particular cross, plants the height of which was shorter than 135 to 155 cm., and by tall plants the height of which was shorter than 160 cm. to 180 cm. or more. The ratio of the plants under the dwarf group to the plants under the tall was 3.15 : 0.85. This ratio agreed with the Mendelian monohybrid ratio of 3 : 1. The probability per 100 was 17.73 when the goodness of fit was considered (see outline 6).

OUTLINE 6.—*Grouping the F₂ plants of Cross No. 6 based on the modal heights of the two parents and F₁ plants*

Imported parent, Connecticut Havana × *Native parent, Repollo*
 Modal height, 180 cm. Modal height, 180 cm.
 Mean of parent modes, 180 cm.

Modal height of 84 F₁ plants, 135 cm.

Classes of 246 F₂ plants studied
 Modal height, 180 cm.

Dwarf	Medium	Tall
Shorter than	Shorter than	Taller than
135 to 155 cm.	160 to 180 cm.	185 cm.
52 plants	88 plants	106 plants

Ratio, 0.85 : 1.43 : 1.72.

The results in Cross No. 7 which was between Connecticut Havana and Dammas Broad Leaf, need not be considered in detail. The range of variability exhibited by the parents, F₁ and F₂ plants was as follows:

Connecticut Havana.....	45 to 255 cm.
Dammas Broad Leaf.....	30 to 195 cm.
First generation hybrid.....	90 to 210 cm.
Second generation hybrid.....	60 to 225 cm.

The variation exhibited by F₁ plants was within the limits of the parents' combined. The range of variation in F₂ was greater than in that of F₁ and it was within the limits of the two parents. In the case of Connecticut Havana the

modal height was 180 cm.; Dammao Broad Leaf, 165 cm.; F₁, 135 cm.; and F₂, 165 cm. The ratios obtained for F₂ generation after grouping them into three groups on the basis of mode and means were 2.14 : 1.22 : 0.64 for mode and 0.45 : 3.12 : 0.43 for mean (see table 10). These did not agree with the monohybrid ratio.

TABLE 10
Classification of F₁ and F₂ plants of Cross No. 7 according to the modes and means of the two parent plants

	HEIGHT		
		Mode	Mean
Imported parent, Connecticut Havana.....		180 cm.	185.7464 cm.
Native parent, Dammao Broad Leaf.....		165 cm.	136.4795 cm.
GROUPS BASED ON MODE			
	Short	Medium	Tall
	Shorter than	Taller than	Taller than
	165 cm.	165 to 180 cm.	180 cm.
F ₁ classes as related to mode.....	47 plants	3 plants	4 plants
F ₁ ratio as related to mode.....	3.48 :	0.22 :	0.30
F ₂ classes as related to mode.....	134 plants	76 plants	40 plants
F ₂ ratio as related to mode.....	2.14 :	1.22 :	0.64
GROUPS BASED ON MEAN			
	Short	Medium	Tall
	Shorter than	Taller than	Taller than
	136.5 cm.	136.5 to 185.7 cm.	185.7 cm.
F ₁ classes as related to mean.....	32 plants	18 plants	4 plants
F ₁ ratio as related to mean.....	2.37 :	1.33 :	0.30
F ₂ classes as related to mean.....	28 plants	195 plants	27 plants
F ₂ ratio as related to mean.....	0.45 :	3.12 :	0.43

Cross No. 7 gave F₁ plants with a modal height of 135 cm. This cross was different from the six crosses already described in that the native parent was shorter than the imported parent.

The F₂ plants were classified into dwarf and tall plants. Dwarf plants were those shorter than 135 to 150 cm. and the tall plants were those with a height between 155 and 180 cm. or more. The actual ratio of segregation was 2.90 : 1.10. This followed the monohybrid ratio of 3 : 1 with probability per 100 of 38.06 (see outline 7).

OUTLINE 7.—*Grouping the F₂ plants of Cross No. 7 based on the modal heights of the two parents and F₁ plants*

<i>Imported parent, Connecticut Havana</i>		×	<i>Native parent, Dammao' Broad Leaf</i>	
Modal height, 180 cm.			Modal height, 165 cm.	
Mean of parent modes, 172.5 cm.				
Modal height of 54 F ₁ plants, 135 cm.				
Classes of 250 F ₂ plants studied				
Modal height, 165 cm.				
<i>Dwarf</i>	<i>Medium</i>		<i>Tall</i>	
Shorter than	Shorter than		Taller than	
135 to 150 cm.	155 to 175 cm.		180 cm.	
69 plants	118 plants		63 plants	
Ratio, 1.10 : 1.89 : 1.01.				

Height is one of the characters of the tobacco plant, which in the F_1 generation, and as found in the seven crosses just discussed, is not exactly intermediate between the two parents. The results of the seven crosses reported in this paper were not uniform with respect to height.

The typical heights of the F_2 plants were, in the seven crosses studied, higher than F_1 individuals. It is very interesting to note in the case of Cross No. 6 where both parent varieties were identical in height, that the F_2 individuals exhibited a marked increase in height. This can probably be explained by the law of heterosis.

The F_2 generation of Cross No. 1 represented very striking features. It showed a unimodal curve which did not show segregation as the other crosses did. The F_2 in crosses Nos. 1, 2, 6, and 7 segregated within the limits of the parent plants, while in crosses Nos. 3, 4, and 5 the F_2 exhibited an average height beyond the limits of their parents.

TABLE 11

Summary of tests of the goodness of fit of the actual ratios of the dwarf and tall plants, based upon the mean heights of the parent plants

CROSS NO.	ACTUAL NO. OF INDIVIDUALS		RATIO		DEVIATION	PROBABLE ERROR	DEVIATION INTO PROBABLE ERROR	PROBABILITY PER 100
	Tall	Dwarf	Actual	Theoretical				
1	85	21	3.21 : 0.79 12.83 : 3.17	3 : 1 15 : 1	0.21 2.17	0.113 0.262	1.8 8.4	22.47 Poor fit
2	174	2	15.82 : 0.18 63.27 : 0.73	15 : 1 63 : 1	0.82 0.27	0.206 0.413	3.9 0.6	0.853 More than 50 Very good fit.
3	163	30	3.38 : 0.62 13.51 : 2.49	3 : 1 15 : 1	0.38 1.49	0.084 0.180	4.4 7.9	0.300 .0000291
4	174	36	3.31 : 0.69 13.26 : 2.74	3 : 1 15 : 1	0.31 1.74	0.081 0.180	3.9 9.6	0.853 Poor fit
5	212	48	3.26 : 0.74 13.04 : 2.96	3 : 1 15 : 1	0.26 1.96	0.072 0.169	3.6 12.0	1.52 Poor fit
6	170	76	2.76 : 1.24 11.06 : 4.94	3 : 1 15 : 1	0.24 3.94	0.074 0.172	3.1 23.6	3.65 Poor fit
7	222	28	3.55 : 0.45 14.21 : 1.79	3 : 1 15 : 1	0.55 0.79	0.073 0.170	7.5 4.8	0.00014072 0.121

Table 11 shows the results of testing the goodness of fit of the ratios obtained, as compared with Mendelian ratios, 3 : 1, 15 : 1, and 63 : 1. The individuals in each cross were divided into two groups as shown in the second and third columns of table 11. The method of testing the fit is explained in the first part of this paper. The last column of table 11 shows which of the theoretical ratios, 3 : 1, 15 : 1, and 63 : 1 fitted the actual ratios of the crosses studied.

Based upon the mean height of the parent varieties, crosses Nos. 1, 3, 4, 5, and 6 fitted ratio 3 : 1 better than they did 15 : 1, while Cross No. 7 fitted 15 : 1 better than it did 3 : 1. Cross No. 2 fitted 63 : 1 better than it did either 3 : 1 or 15 : 1.

NUMBER OF LEAVES ON EACH PLANT

Number of leaves per plant was determined and its inheritance was studied in the F_1 and F_2 generations. This character was measured as follows: The individual plants in each plot were numbered and labeled with Dennison tags as in the study of height. After all the leaves worth harvesting were gathered, the plants were uprooted, washed clean, and all the leaf scars and the remaining leaves counted.

It should be understood that in this investigation no study was undertaken to ascertain the effect of environment on the number of leaves on each plant. Howard (1913) found that changes in a normal environment have little effect on this character. According to Hayes (1914) the number of leaves per plant was little affected by environment, unless the conditions were so unfavorable as to greatly stunt or dwarf the plant.

In the seven crosses studied it was found that the F_1 generations were more or less intermediate between the parents. They were within the limits of the variability of the parents combined. The F_2 generations had a range far outside those of the F_1 generations, with the exception of crosses Nos. 2 and 3.

Cross No. 1 showed that the range of variability of number of leaves of Improved Gold Leaf was between 21 and 39. The number of leaves of Repollo ranged from 20 to 36. The F_1 plants gave a range of 27 to 40, while F_2 individuals gave a range of 22 to 38.

Improved Gold Leaf with a mean number of leaves 28.85 ± 0.1373 , was crossed with Repollo which had a mean number of leaves of 30.32 ± 0.1465 . The mean number of leaves of 98 F_1 plants obtained from Cross No. 1 was 30.19 ± 1.1703 , a value which differs from the average mean of 29.58 of the two parents. There were 106 F_2 plants studied in this cross.

The striking feature of the F_2 plants was that in number of leaves the frequency distribution follows practically a dimodal curve, the modes corresponding approximately to those of the parents and of F_1 plants. Also both parents gave the same modes as to number of leaves. The F_2 plants were grouped according to the means of the two parents.

Comparing the mean of the parents with the means of F_1 , it was found that the F_1 plants gave a greater mean than did the parents combined. The segregation in F_2 is shown in table 12. The ratio in the F_2 generation, as shown in table 12, was 1.9 : 1.0 : 1.1. The F_2 plants were more variable than

TABLE 12

Classification of F_1 and F_2 plants of Cross No. 1 according to the means of the two parent plants

NUMBER OF LEAVES			
	Mode		Mean
Imported parent, Improved Gold Leaf.....	29 leaves		28.85 leaves
Native parent, Repollo.....	29 leaves		30.32 leaves
GROUPS BASED ON MEAN			
	<i>Few</i> Less than 29 leaves	<i>Medium</i> More than 28 to 30 leaves	<i>Many</i> More than 30 leaves
F_1 classes as related to mean.....	17 plants	45 plants	56 plants
F_1 ratio as related to mean.....	0.7	1.8	1.5
F_2 classes as related to mean.....	50 plants	27 plants	29 plants
F_2 ratio as related to mean.....	1.9	1.0	1.1

the F_1 plants and the two parent varieties. This is the reason every practical plant breeder should carefully isolate the desired type for future work. Unless the homozygous type is isolated in F_2 , the chances are that the future generations will segregate or degenerate, as in the case of Tirona Hybrid, the first tobacco hybrid produced in the College of Agriculture. The test for this hybrid was not carried beyond the second generation.

OUTLINE 8.—Grouping the F_2 plants of Cross No. 1 based on the modes of the two parents and F_1 plants

Imported parent, Improved Gold Leaf × *Native parent, Repollo*
Mode, 29 leaves Mode, 29 leaves

Mode of 98 F₁ plants, 29 leaves

Classes of the 106 F₂ plants studied
Mode. 29 leaves

<i>Few</i>	<i>Many</i>
Less than 29 leaves	More than 28 leaves
50 plants	56 plants

Ratio, 1.9 : 2.1

Grouping the 106 F₂ plants into "few" and "many" leaves, it was found that there were 50 F₂ plants which could be classified under "few." The plants under this group had less than 29 leaves. There were 56 F₂ plants that had 29 or more leaves. These were put under the class "many." The ratio of the F₂ plants under the two groups was 1.9 : 2.1. This was very good agreement with the modified Mendelian ratio of 9 : 7 (see outline 8). The probability per 100 in this case was more than 50.00. It is, therefore, almost a certainty (see table 19).

Cross No. 2 was between Improved Gold Leaf which had a typical number of leaves of 29 and San Antonio which had a typical number of leaves of 41 per plant. The F_1 had 41 and F_2 44 typical number of leaves per plant. An increase number of leaves per plant was seen in F_2 .

The 93 F₁ plants studied had a wide range of variability. This might have been due to the parent plants of the F₁ individuals being heterozygous. The limits of variability of the F₂ generation were not so broad as those of the parents combined, but with the F₁ plants, they were broader. The F₂ plants of this cross, like those of Cross No. 1, presented many modes. There were more plants in F₂ than in the parents which showed a greater number of leaves. With regard to inheritance of the number of leaves per plant, it is very clear that this character is heritable and that segregation occurred in F₂. The striking feature showed in this particular cross was an increase of 3 leaves obtained in F₂ over the native parent, San Antonio, and over F₁ population, and of 9 leaves over the average of the two parent plants. The plants were divided into groups based on the mean and modal number of leaves of the parents. The ratio as related to mode and mean was 1.6 : 2.4. There were no plants in F₂ generation with less than 29 leaves, the modal number of Improved Gold Leaf.

TABLE 13

Classification of F_1 and F_2 plants of Cross No. 2 according to the modes and means of the two parent plants

	NUMBER OF LEAVES	<i>Mode</i>	<i>Mean</i>
Imported parent, Improved Gold Leaf.....	29 leaves	28.85 leaves	
Native parent, San Antonio.....	41 leaves	40.89 leaves	

GROUPS BASED ON MODE

	<i>Few</i> Less than 32 leaves	<i>Medium</i> More than 31 to 35 leaves	<i>Many</i> More than 35 leaves
F ₁ classes as related to mode.....	70 plants	18 plants	8 plants
F ₁ ratio as related to mode.....	2.9 :	0.8 :	0.3
F ₂ classes as related to mode.....	52 plants	84 plants	57 plants
F ₂ ratio as related to mode.....	1.1 :	1.7 :	1.2

GROUPS BASED ON MEAN

	<i>Few</i> Less than 33 leaves	<i>Medium</i> More than 32 to 35 leaves	<i>Many</i> More than 35 leaves
F ₁ classes as related to mean.....	73 plants	18 plants	5 plants
F ₁ ratio as related to mean.....	3.0 :	0.8 :	0.2
F ₂ classes as related to mean.....	69 plants	85 plants	39 plants
F ₂ ratio as related to mean.....	1.4 :	1.8 :	0.8

On the basis of the means of the two parents the 193 F₂ plants were classified under three groups. The actual number of F₂ plants under each group are given in table 14. The actual ratio of segregation was 1.4 : 1.8 : 0.8.

Cross No. 3 gave a mode of 26 leaves in the F₁ generation, which was less than that of either parent. Classifying the 193 F₂ plants under two groups as shown in outline 10, the actual ratio of the observed numbers was 1.4 : 2.6. This agreed better with the ratio of 27 : 37 of Mendel with a probability of 7.95 per 100, than either 3 : 1 or 9 : 7.

OUTLINE 10.—Grouping the F₂ plants of Cross No. 3 based on the modes of the two parents and F₁ plants

Imported parent, Connecticut Havana × Native parent, San Juan Batec
Mode, 32 leaves Mode, 35 leaves

Mode of 96 F₁ plants, 26 leaves

Classes of the 193 F₂ plants studied
Mode, 35 leaves

<i>Few</i>	<i>Many</i>
Less than 33 leaves	More than 32 leaves
69 plants	124 plants
Ratio, 1.4 : 2.6	

Cross No. 4 was between Connecticut Havana with 18 to 42 leaves per plant and Romero, with 25 to 47 leaves per plant. 92 F₁ plants showed a range of variability of 24 to 42 leaves. This range was almost intermediate between the variability of the parents combined. The striking feature of the F₁ plants was, that they gave a ratio of 1.4 : 1.6 : 1.0 which could be satisfactorily compared with a 1 : 2 : 1 ratio. The segregation in F₂ plants was very evident, although the ratio did not follow monohybrid ratio when the modes of the two parents were considered. These F₂ plants when grouped according to the means of the two parents, as shown in table 15, gave a ratio of 0.5 : 2.2 : 1.3 which can be satisfactorily compared with the Mendelian modified ratio of 1 : 2 : 1.

The F_2 plants were divided into the "few" and "many" as shown in outline 12. The observed numbers have a ratio of 0.1 : 3.9. The observed numbers of F_2 plants under the two groups were tested as to goodness of fit. The test showed that the ratio of segregation fitted 63 : 1 better than it did either 15 : 1 or 1 : 1. The probability per 100 for the ratio 63 : 1 was 34.50, and for ratio 15 : 1, 1.04.

Cross No. 6 was between Connecticut Havana and Repollo. The range of variability follows:

Repollo.....	20 to 36 leaves.
Connecticut Havana.....	18 to 42 leaves.
First generation hybrid.....	18 to 43 leaves.
Second generation hybrid.....	17 to 43 leaves.

The second generation showed a wider range of variability than the two parents combined. The 246 F_2 plants segregated in the ratio of 1.2 : 2.0 : 0.8 based on the means of the two parents as shown in table 17. This was approximately a 1 : 2 : 1 ratio. The ratio of segregation based on the modes of the parent plants was 0.9 : 1.4 : 1.7. This may be compared very favorably with 1 : 2 : 1 ratio or with 3 : 1 if the "medium" and "many" groups as shown in table 17 are considered as one group.

TABLE 17

Classification of F_1 and F_2 plants of Cross No. 6 according to the modes and means of the two parent plants

NUMBER OF LEAVES			
		Mode	Mean
Imported parent, Connecticut Havana.....		32 leaves	33.04 leaves
Native parent, Repollo.....		29 leaves	30.32 leaves
GROUPS BASED ON MODE			
	Few Less than 29 leaves	Medium More than 28 to 31 leaves	Many More than 31 leaves
F_1 classes as related to mode.....	5 plants	17 plants	62 plants
F_1 ratio as related to mode.....	0.2	: 0.8	: 3.0
F_2 classes as related to mode.....	54 plants	85 plants	107 plants
F_2 ratio as related to mode.....	0.9	: 1.4	: 1.7
GROUPS BASED ON MEAN			
	Few Less than 30 leaves	Medium More than 29 to 33 leaves	Many More than 33 leaves
F_1 classes as related to mean.....	9 plants	47 plants	28 plants
F_1 ratio as related to mean.....	0.4	: 2.3	: 1.3
F_2 classes as related to mean.....	71 plants	125 plants	50 plants
F_2 ratio as related to mean.....	1.2	: 2.0	: 0.8

OUTLINE 13.—Grouping the F_2 plants of Cross No. 6 based on the modes of the two parents and F_1 plants

Imported parent, Connecticut Havana	×	Native parent, Repollo
Mode, 32 leaves		Mode, 29 leaves
Mode of 84 F_1 plants, 32 leaves		
Classes of the 246 F_2 plants studied		
Mode, 32 leaves		
Few		Many
Less than 32 leaves		More than 31 leaves
139 plants		107 plants
Ratio, 2.26 : 1.74		

Cross No. 6 shows that most of the plants had 32 leaves; this was 3 leaves more than the native parent. The F_2 plants were classified into two groups as shown in outline 13. The modes of the F_1 and F_2 plants were the same. In this cross the mode of the native parent was less than the imported one with respect to the number of leaves per plant. When the observed numbers were tested for the goodness of fit, it was found that they fitted the Mendelian ratio of 9 : 7 better than they did the ratios of 1 : 1 and 27 : 37. The probability of 9 : 7 ratio per 100 was more than 50.00. The probability in this case, therefore, was almost a certainty.

Cross No. 7 was between Connecticut Havana and Dammas Broad Leaf and showed limits of variability as follows:

Connecticut Havana..... 18 to 42 leaves.

Dammao Broad Leaf.....	23 to 42 leaves.
------------------------	------------------

First generation hybrid.....	27 to 41 leaves.
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Second generation hybrid..... 18 to 39 leaves.

It will be seen that the F_1 distribution occupied a position midway between the two parents. The number of hybrid plants grown was somewhat smaller than those for the parents, and this fact might explain the smaller range of variability of the F_1 . The coefficient of variability of F_1 was greater than the coefficient of variability of the native parent but not greater than that of the imported parent plants. When the F_2 plants of this cross were considered, it was found that although they showed segregation like the F_1 , the range of variability was within the limits of either parent. The coefficient of variability in the F_2 generation was greater than either the parent varieties or F_1 plants. The segregation in F_2 , as related to the means of the two parent varieties was very different from the other crosses. Table 18 shows the number of plants under each group

TABLE 18

TABLE 18
Classification of F_1 and F_2 plants of Cross No. 7 according to the modes and means of the two parent plants

<i>plants</i>	NUMBER OF LEAVES	<i>Mode</i>	<i>Mean</i>
Imported parent, Connecticut Havana.....		32 leaves	35.04 leaves
Native parent, Dammao Broad Leaf.....		32 leaves	31.72 leaves
	GROUPS BASED ON MEAN		
	<i>Few</i>	<i>Medium</i>	<i>Many</i>
	Less than	More than	More than
	32	31 to 33	33
	leaves	leaves	leaves
F ₁ classes as related to mean.....	27 plants	9 plants	18 plants
F ₁ ratio as related to mean.....	2.0 :	0.7 :	1.3
F ₂ classes as related to mean.....	192 plants	23 plants	35 plants
F ₂ ratio as related to mean.....	3.1 :	0.3 :	0.6

and the ratio of F_2 plants as related to mean. The imported and native parents gave the same mode as to number of leaves. The plants in F_2 were only classified based on the means of their parent plants.

OUTLINE 14.—Grouping the F_2 plants of Cross No. 7 based on the modes of the two parents and F_1 plants

Imported parent, Connecticut Havana $\times$ Native parent, Dammas Broad Leaf
Mode, 32 leaves Mode, 32 leaves

• Mode of 54 F₁ plants, 29 leaves

Classes of the 250 F₂ plants studied
Mode, 29 leaves

Table 19 shows the results of testing the goodness of fit of the ratios obtained as compared with Mendelian ratios, 1 : 1, 3 : 1, 9 : 7, 15 : 1, 27 : 37, and 63 : 1. The individuals in each cross were divided into two groups as shown in the third column of table 19. The method of testing the goodness of fit is briefly explained. The actual numbers of F_2 under "few" and "many" groups for each cross were determined and compared with the theoretical numbers in order to find the deviations in numbers. The probable errors were figured out according to this formula:

$$P. E. = \pm 0.6745 \sqrt{p \cdot q \cdot n}.$$

The deviation divided by the probable error, we could find the probable number of times in 100 trials from Pearl's table of probable error of Mendelian ratios.

From the results in the seven crosses reported in this paper it was evident that each cross had its own ratio of segregation to follow in regard to number of leaves. The following theoretical F_2 ratios were found most fitted with the actual ratio obtained in each cross:

Crosses No. 1 and No. 6.....	9 : 7,
Cross No. 2.....	3 : 1,
Cross No. 3.....	27 : 37,
Cross No. 4.....	15 : 1,
Cross No. 5.....	63 : 1,
Cross No. 7.....	1 : 1,

INHERITANCE OF ARRANGEMENT OF LEAVES ON THE STEM

This character was studied before the leaves were harvested. The habit of growth of a tobacco plant depends upon the arrangement of the leaves on the main stem and on the inclination of the leaves, whether upright or drooping. It is claimed by some authorities that an economically profitable plant should have the greater number of its leaves in an upright position. These leaves should be on a stem of medium height and be borne towards the base of the stem. In studying the inheritance of arrangement of leaves in this work, the plants were divided into three types following Howard (1913): Type (A) plants which carry all their large leaves at the base of the stem and as a consequence the leaves lie on the ground; (B) plants which bear the majority of their large leaves near the base, and the rest upon the stem; (C) plants on which the leaves are borne at equal intervals on the stem. The inheritance of arrangement of leaves was studied in F_2 plants with their corresponding parent varieties in the same year.

The plants in all the plots were numbered and examined carefully before all the leaves were harvested. Dennison tags were used in labeling them. In examining each plant to determine to which of the three types it belonged, a photograph of each group was used to compare with the plant under examination. It was hoped from the study of this particular character to obtain a type for economic purposes. The results obtained in this study are given in table 20.

TABLE 20

Classification of the plants according to the arrangement of leaves on the stem

PARENTS AND HYBRIDS	NUMBER OF PLANTS STUDIED	TYPE A	TYPE B	TYPE C
		Plants which carry all their large leaves at the base of the stem and as a consequence the leaves lie on the ground	Plants which bear the majority of their large leaves near the base and the rest upon the stem	Plants on which the leaves are borne at equal intervals on the stem
Connecticut Havana.....	355	0	2	353
San Juan Batec.....	275	1	274	0
Hybrid No. 3, F ₂	193	45	43	105
Ratio.....		1.0	0.9	2.1
Improved Gold Leaf.....	261	0	254	7
Romero.....	176	0	4	172
Hybrid No. 5, F ₂	260	62	65	133
Ratio.....		1.0	1.0	2.0
Connecticut Havana.....	355	0	2	353
Repollo.....	159	6	153	0
Hybrid No. 6, F ₂	246	85	58	103
Ratio.....		1.3	1.0	1.7
Connecticut Havana.....	355	0	2	353
Dammao Broad Leaf.....	98	0	97	1
Hybrid No. 7, F ₂	250	66	126	58
Ratio.....		1.0	2.0	1.0

In the cases of the crosses Nos. 3, 5, 6, and 7, distinct types were crossed. Cross No. 3 was the result of crossing San Juan Batec in which the majority of the large leaves are borne near the base and the rest up the stem, and Connecticut Havana in which the leaves are borne at equal intervals up the stem. Short and tall plants alike were found in F₂ generation. The F₂ plants were found to belong to the three groups as indicated in table 20. The ratio of the three groups was 1.0 : 0.9 : 2.1. If the F₂ plants in Cross No. 3 are placed under two groups, classifying Types A and B (table 20) under one group, and Type C under another, it may be seen that there were 88 F₂ plants under the group to which the native parent belonged and 105 F₂ plants under the type of the imported parent. The actual ratio of segregation in F₂ per 2 of the groups on the basis of 1 : 1 was 1.09 : 0.91. The probability per 100 of this ratio was 22.47 when the goodness of fit was considered. Most of the F₂ plants studied assumed the arrangement of the leaves on the imported parent. Segregation was very evident.

Cross No. 5 was between Improved Gold Leaf, in which the majority of the large leaves are borne near the base, and the rest upon the stem, and Romero, in which the leaves are borne at equal intervals on the stem. The ratio of the three types was 1.0 : 1.0 : 2.0. The greater number of the plants in F₂ appeared similar to the type to which Romero belonged. The plants in F₂ were found to belong to the three types. When the F₂ individuals in Cross No. 5 were classified under two groups, putting Types A and B under one group and Type C under another, it may be seen that there were 127 F₂ plants under Types A and B and 133 F₂ plants under Type C (see table 20). The actual ratio per 2 of segregation in F₂ generation of the groups on the basis of 1 : 1 was 1.02 : 0.98. The probability per 100 of this ratio when the goodness of fit was considered is more than 50.00. It is, therefore, almost a certainty. Of course, the only accurate method of classifying these individuals included in the types is to test them by

growing their F_2 progeny. If they belong to the homozygous group they should breed true to type, whereas if they belong to the heterozygous group they should segregate further.

Cross No. 6 presented no striking feature. This was a cross between Connecticut Havana and Repollo. The ratio exhibited by the F_2 population was 1.3 : 1.0 : 1.7. The F_2 plants in Cross No. 6 can be classified into two groups, Types A and B could be named as first group. The native parent, Repollo, belonged to Type B. Type C could be considered as second type to which the imported parent, Connecticut Havana, belonged. There were 143 F_2 plants under the first type and 103 F_2 plants under the second type (see table 20). The actual ratio of segregation in F_2 per 2 of the groups on the basis of 1 : 1 was 0.8 : 1.2. The probability per 100 of this ratio when the goodness of fit was considered was 1.26.

Cross No. 7 was between Connecticut Havana in which the leaves are borne at equal intervals upon the main stem, and Dammao Broad Leaf in which the majority of the large leaves are borne near the base, the rest upon the stem. It may be seen in table 20 that the ratio was 1.0 : 2.0 : 1.0. Classifying the F_2 plants in Cross No. 7, there were 192 plants which fell under Types A and B. These F_2 plants were considered as one group. There were 58 F_2 plants under Type C to which the imported parent, Connecticut Havana, belonged. The native parent, Dammao Broad Leaf, belonged to Type B (see table 20). The actual ratio per 4 of the F_2 segregation of the groups on the basis of 3 : 1 was 3.07 : 0.93. The probability per 100 of the goodness of fit as figured out was more than 50.00. It is, therefore, almost a certainty.

From the results in the inheritance of the arrangement of leaves on the stem, it is seen that crosses Nos. 3, 5, 6 segregated according to theoretical ratio 1 : 1 but Cross No. 7 followed 3 : 1.

GENERAL CONCLUSIONS

The general conclusions in this investigation may be summarized as follows:

1. The segregation of F_2 plants in the second generation as to age of flowering is evident, although it did not follow uniformly any one definite ratio. By careful attention to breeding details it seems quite possible to isolate a plant flowering earlier than its parents. The F_2 plants in crosses Nos. 2 and 4 were more variable in their age of flowering than either the imported or the native parent variety.

2. Distinct F_2 segregation was observed as regards height of plant. The F_1 generations were not always intermediate between the parent varieties. The F_2 plants in crosses Nos. 1, 3, 4, 5, and 6 segregated into tall and dwarf plants according to Mendelian monohybrid ratios of 3 : 1. Crosses Nos. 2 and 7 followed 63 : 1 and 15 : 1 ratios, respectively. This was true when the classifications of the F_2 plants were based upon the means of the parent varieties. Based upon the modal heights of the parent varieties, the segregation into tall and dwarf plants followed the ratio 3 : 1 with the exception of the F_2 plants in Cross No. 5 which followed 2 : 2 ratio. The variability in height of the F_2 plants was greater than that of the F_1 plants. When the F_2 individuals were classified into tall

and dwarf plants based upon the modal heights of their corresponding parent varieties, the theoretical ratios of segregation followed by each cross was as follows:

Cross No. 1.....	3 : 1,
Cross No. 2.....	3 : 1,
Cross No. 3.....	3 : 1,
Cross No. 4.....	3 : 1,
Cross No. 5.....	2 : 2,
Cross No. 6.....	3 : 1,
Cross No. 7.....	3 : 1.

3. The number of leaves per plant is entirely independent of the height of the plant and environment. The ratio of segregation followed by the F_2 plants in each cross as to the number of leaves per plant was different from the ratio followed for height by the same cross. No one cross reported in this paper segregated in the same Mendelian ratio for the number of leaves per plant and for height. The segregation of F_2 individuals for the number of leaves per plant followed different Mendelian ratios as evidenced by the test of goodness of fit of the observed numbers in each cross. It may be possible to isolate a plant with increased number of leaves by crossing. Great range of variability in the F_2 generation was evident. In number of leaves per plant each cross has its own theoretical ratio to follow in the F_2 generation with the exception of crosses Nos. 1 and 6 which had the same ratio of segregation.

4. Arrangement of leaves on the stem of tobacco plant followed different ratios. Crosses Nos. 3, 5, and 6 segregated into 1 : 1 while Cross No. 7 segregated into 3 : 1. The variability of F_2 population from the crosses reported in this paper was much greater than that of the F_1 population and parent varieties.

5. The tests of goodness of fit showed that crosses Nos. 2 and 7 followed the monohybrid ratio while the other crosses manifested that disturbing forces were in operation in the experiment. The theoretical ratios of segregation followed by each cross as to number of leaves per plant was as follows:

Cross Nos. 1 and 6.....	9 : 7,
Cross No. 2.....	3 : 1,
Cross No. 3.....	27 : 37,
Cross No. 4.....	15 : 1,
Cross No. 5.....	63 : 1,
Cross No. 7.....	1 : 1.

6. The number of factors actually involved in the inheritance of the number of leaves per plant may be from one to three.

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PLOWS AND PLOWING I: PLOWING, A POWER-CONSUMING OPERATION ON THE PHILIPPINE FARM¹

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Statistical Bulletin No. 5 issued by Philippine Bureau of Commerce and Industry shows that in 1922 a total of approximately 2,453,463 hectares of cultivated land was devoted to the culture of rice, corn, sugar cane, and tomatoes. This area represents roughly the amount of land cultivated yearly with the aid of native plows.

Plowing is generally done twice before planting. Plowing the field three times is, however, a very common practice in the case of upland rice, corn, and tomatoes. In sugar cane plantations, in certain localities, the operation is repeated as many as seven times. This process, gone through year after year, is indicative of the labor required to maintain the ground in a fine, mellow tilth.

In view of the large amount of mechanical energy expended annually in the preparation of land, it was deemed advisable to make as detailed a study as possible of the principal implement used—the homemade plow. This study includes the different makes of these plows, their action in different kinds of soils under varying conditions, methods of hitch, speed of the animal, and draft.

In the study an attempt is made by the writer to compute, approximately, the total energy expended in annual plowing on land grown to the crops listed above in the Philippines, from the results of a preliminary investigation on the drafts of native plows in the College of Agriculture, Los Baños. The results of a series of tests on these drafts of native plows are presented in table 1:

TABLE 1
Draft tests with corresponding average speed

KIND OF SOIL	CONDITION OF SOIL	WIDTH OF FURROW	DEPTH OF FURROW	TOTAL DRAFT	SPEED OF BULLOCK
		cm.	cm.	kgm.	km/hr.
Clay loam.....	Extremely dry, weedy.....	18.5	10.9	60.6	1.5
Clay loam.....	Moderately moist, weedy.....	20.2	8.8	53.7	1.9
Clay loam.....	Ideal.....	19.7	13.5	60.3	1.4
Loamy clay.....	Very dry, hard.....	20.2	11.2	86.5	1.8
Clay loam.....	Corn stubble.....	18.7	10.8	85.4	1.9
Clay loam.....	Second plowing, slightly weedy.....	19.8	12.6	50.7	2.0
Clay loam.....	Third plowing, slightly weedy.....	20.8	13.8	45.8	2.4
Average ^a		19.5	11.0	69.3	1.7

^a Average of first five times only.

Considering the values here given as the average total draft and the average speed used in plowing 2,453,463 hectares, the cultivated area reported in 1922, the horsepower-hour can be computed as approximately 0.431. Roughly estimat-

¹ Experiment Station contribution No. 292.

ing the actual time required to plow a hectare of land as 30 hours, approximately 13 horsepower-hours will be required. In the total area under consideration, the first plowing alone requires an energy expenditure of approximately 31,895,000 horsepower-hours. This amount of energy results only in turning the soil over once in one season, an operation which, taking into consideration the quality of the work done by the majority of native plows, consists principally of merely breaking the soil into large clods and inverting or partially inverting the furrow slice. The land, however, has to be harrowed and plowed several times until a mellow seed bed of suitable depth is produced; for the maximum value for the horsepower expended is naturally obtainable only after the requisite amount of cultivation is done to meet the requirements of a particular crop.

As stated above, the total amount of mechanical energy expended for the limited acreage taken into account in the present paper runs into millions of horsepower-hours. Although merely an estimate, still these figures are believed to be as near the actual facts as it is possible to approach them by calculation. It will be seen, then that this one operation alone, plowing, consumes a very large, if not the largest, amount of work done in crop production.

A STUDY OF MENDELIAN INHERITANCE IN NATURAL HYBRIDS OF ROSAL (*GARDENIA FLORIDA*, L.)¹

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WITH ONE PLATE AND ONE TEXT FIGURE

The rosal (*Gardenia florida*, L.) is an ornamental shrub generally found in Philippine dooryards. It produces fairly large, pure white, very fragrant flowers which are borne singly on the upper axils. While the gomamela (*Hibiscus rosasinensis*) interests because of its many color varieties, the interest of the rosal plant lies in the whiteness and the sweet odor of its flowers. It is the rich creamy petals and the heavy sweet fragrance of the rosal that make it popular for ornamental hedges or as individual plants in the yard.

There are two common types of rosal. The first and the more common type is that which has three sets of petals. The second type has two sets of petals. Both types of flowers are generally known as double. In fact, rosal is generally described as having double corollas.

The present paper is a third report of the Division of Plant Breeding on attempts to produce new seedling types of the common Philippine ornamentals which are generally propagated by vegetative means.

MATERIALS USED

The seedling types here reported are seedling offspring of a parent variety bearing three corollas. The fruit of rosal is ellipsoid in shape and reddish inside. It contains many seeds, about a hundred or more. The seeds are rather flat, resembling very much, except in color, the seed of the tomato and the eggplant.

On February 28, 1923, seeds from two fruits of rosal were planted, employing the ordinary method of germination. The seeds germinated within a month. On July 20, 1923, fifty-four seedlings were transplanted in the experimental plot of the Plant Breeding Nursery.



FIG. 1. (a) Rosal fruit, natural size;
(b) Rosal seed, natural size.

¹ Experiment Station contribution No. 293. The writer is indebted to Dr. N. B. Mendiola and Mr. J. O. Unite, both of the Division of Plant Breeding, Department of Agronomy, for aid in carrying out this study.

DESCRIPTION OF RESULTS

Variability in flowering season. The culture began to flower in early June, 1924, or about a year after the plants were transplanted. Observation on flowering was made as soon as the flower buds appeared on the upper axils of the plants. Of the fifty-four seedlings transplanted, twenty-five have flowered up to the present time (November, 1924). These plants bore flowers during the months of June, July, and August. After the month of August none of the seedlings, other than the twenty-five, showed signs of blooming. Some of the twenty-five plants were profuse producers of flowers, while others were shy producers.

Variability in flower characteristics. In the present study of floral characteristics of rosal seedlings, the word, "double" is taken to mean more than one corolla or set of petals. In the description of types therefore, "single" refers to one corolla, while "double" means multiple corollas; that is, among the double flowers we may have flowers consisting of two, three, or four sets of petals.

The seedlings exhibited a variable number of corollas, ranging from single to multiple. The petals of the different seedlings vary in size and form. Some flowers (see plate I) are larger than the ordinary kind and some are of such reduced size that, were it not for the odor, they might be taken for flowers of some other species.

Variability in fruiting habit. Of the twenty-five seedlings under report, ten fruited while fifteen did not. This fact suggests that the fifteen are self-sterile. The ten that fruited are self-fertile. There is correlation between shape of fruit and multiplicity of corolla. Double-flowered plants produced nearly spherical fruits while the single-flowered ones produced rather elongated fruits.

TABLE 1

Variability in date of flowering type of corolla and fruiting habit of rosal seedlings

SEEDLING NUMBER	DATE OF FLOWERING, 1924	TYPE OF COROLLA	NUMBER OF PETALS OR SETS OF PETALS	FRUITING OR NOT FRUITING
5	August 11	Double	Four sets	Fruiting
6	June 13	Single	Six petals	Fruiting
7	August 6	Double	Three sets	—
8	July 10	Double	Two sets	—
10	June 10	Double	Two sets	Fruiting
12	June 15	Single	Six petals	—
13	June 25	Single	Six petals	—
14	June 13	Single	Seven petals	—
15	June 11	Single	Six petals	Fruiting
17	June 16	Single	Six petals ^a	—
20	June 28	Single	Six petals	Fruiting
21	August 4	Single	Six petals	Fruiting
22	July 10	Single	Six petals	—
26	June 13	Single	Five petals ^b	—
30	June 26	Double	Four sets	Fruiting
32	June 19	Double	Three sets	Fruiting
33	June 12	Single	Six petals	Fruiting
35	June 25	Double	Four sets	—
38	July 12	Double	Two sets	—
40	June 25	Double	Four sets	—
43	August 8	Double	Four sets	—
46	August 6	Single	Six petals	—
52	August 11	Double	Three sets	—
53	June 17	Double	Four sets	Fruiting
54	August 30	Double	Multiple bracts	—

^a One branch produced double (3 sets) on August 15, 1924.

^b One branch produced a single flower with 6 petals on August 17, 1924.

DISCUSSION OF RESULTS

Table 2 shows how the different seedlings which flowered are grouped as to the type of corolla.

TABLE 2
Showing the corolla type of the seedlings

TYPE OF COROLLA	SEEDLINGS PLANT NUMBERS	TOTAL
Single corolla		
5 petals	26	12
6 petals	6, 12, 13, 15, 17, 20, 21, 22, 33, 46	
7 petals	14	
Double corolla		
2 sets	8, 10, 38	13
3 sets	7, 32, 52	
4 sets	5, 30, 35, 40, 43, 53, 54	

It was possible to predict what type of flowers a seedling will produce on the basis of the characteristics of the flower buds. The plants which produced single flowers had long, slender, and somewhat pointed flower buds, while those which bore a double corolla had short, thick and blunt buds. Of the twenty-five plants which flowered, twelve were single and thirteen were double. Of the singles, one (plant 26) had five petals; ten (plants 6, 12, 13, 15, 17, 20, 21, 22, 33, and 46) had six petals, and one (plant 14) had seven petals. Of the doubles, three were seedlings (plants 8, 10, 38), with two corolla sets; three (plants 7, 32, 52), with three corolla sets and seven (plants 5, 30, 35, 40, 43, 53, 54), with four sets. Judging from the rosal plants most commonly grown, the seedling forms which may be considered new are the singles having five, six, and seven petals, and the doubles with four sets of corolla. These are, at least, different from their parent. Each of these types may be maintained as distinct seedling varieties by vegetative propagation; that is, by cuttings. In this connection, it may be mentioned that rosal can be grown easily by cuttings. The hard or soft wood cuttings of branches or twigs which are not in flush serve as good planting materials.

Suspected cases of bud variation. On two rosal seedlings a change in the number of floral parts from single to multiple was observed taking place within the individual plant. Probably this is a case of a mutation, a phenomenon quite common in ornamental shrubs. The first case was that of plant 17, which, on June 16, gave a single flower with six petals. On August 15, however, a branch of this same plant showed a double flower having three sets of corolla. Another case was exhibited by plant 26, which, on June 13, produced single flowers having five petals. This same plant, on August 17, gave on one of its branches a flower with six petals.

SEEDLING TYPES PROBABLY OF HYBRID ORIGIN

The parent of the seedlings under report is of a three corolla type. The appearance of doubles and singles in the offspring is probably due to hybridity of the parent. The rosal plant has a perfect flower. Its club-shaped stigma and sessile stamens are borne close to each other. Natural crossing or selfing may not be an unusual process in this plant. The strong fragrance of the flower is a great help in attracting insects which act as pollinating agents. However, self-fertilization is probably the rule in rosal. This is evidenced by the arrange-

ment of the stigmas and anthers and the occasional presence of fruits on some rosal plants grown in scattered isolated spots. It can be assumed, then, that the original fruit from which these seedlings were grown was a hybrid heterozygous to multiplicity of corolla. In other words, while the plant has double flowers it has in its genetic equipment a factor or factors for single flowers. The seedlings show thirteen double and twelve single individuals, a proportion which suggests a Mendelian segregation. This observed ratio was compared with different modified Mendelian ratios, 1 : 1; 9 : 7; and 37 : 27; where one, two and three factors, respectively, are concerned in the development of a particular character, in this case, multiplicity of corolla. Table 3 shows the calculation of the closeness of fit of the observed with the three theoretical ratios.

TABLE 3

Showing closeness of fit of a thirteen double and twelve single ratio with Mendelian modified ratios

EXPECTED NUMBERS	RATIO	DEVIATION	PROBABLE ERROR	DEV. P. E.	CLOSENESS OF FIT
12.5000 : 12.5000	1 : 1	0.5000	5.33	0.094	Best fit
14.0625 : 10.9375	9 : 7	1.0625	5.29	0.200	Very good fit
14.4500 : 10.5500	37 : 27	1.4500	5.27	0.275	Good fit

According to the figures given in table 3, multiplicity in corolla sets is probably a Mendelian unit character, doubleness being dominant over singleness. While all the possible modified Mendelian hybrid ratios show significant fit with the observed ratio, the 1 : 1 ratio had the best fit. This would mean that the seedlings represent crosses between a heterozygous plant and a double recessive. If the seedlings be the results of self-fertilization, then the 9 : 7 and the 37 : 27 ratios obtained indicate that more than one factor is necessary to produce doubleness of flowers. Further tests will decide the actual inheritance of this character. It may be remarked that studies on double and single flowers have shown that this character behaved quite differently in heredity. One investigator reported that doubleness is a dominant character. On the other hand, Rasmuson (1921)² working on two *Godetia* species, and Sax (1918)³ on *Chelidonium majus*, found that single flowers are more or less completely dominant over double.

As regards self-fertility, or the natural production of fruits, two views are held. According to one, fertility in flowering plants is a case of sporadic variation. According to the other, it is a Mendelizing unit. The present results incline to the latter view. Table 4 shows how fertility and infertility among the seedlings may have been inherited.

TABLE 4

Showing the closeness of fit of a fifteen not fruiting and ten fruiting ratio with different Mendelian ratios

EXPECTED NUMBERS	RATIO	DEVIATION	PROBABLE ERROR	DEV. P. E.	CLOSENESS OF FIT
12.5000 : 12.5000	1 : 1	2.5000	5.33	0.469	Good fit
14.0625 : 10.9375	9 : 7	0.9375	5.29	0.177	Very good fit
14.4500 : 10.5500	27 : 27	0.5500	5.27	0.104	Best fit

²Rasmuson, H. A genetic study of two *Godetia* species. *Hereditas* 2: 143-289. 1921. (Cited in U. S. Experiment Station Record 45: 643-643. 1921.)

³Sax, K. The inheritance of doubleness in *Chelidonium majus*. *Genetics* 3: 300-307. 1918. (Cited in U. S. Experiment Station Record 41: 223. 1919.)

The figures in table 4 indicate that self-sterility, or non-production of fruits, is dominant over fertility. Referring to the values found, it may be seen that fertility follows the trihybrid modified Mendelian ratios, the best. According to this, three factors are responsible for the natural production of fruits. However, this conclusion should be taken with reservation until further evidence is obtained.

SUMMARY

This paper reports the following:

1. From double parent variety of rosal (*Gardenia florida* L.) the seedlings show singles and doubles.

(a) The singles are of three kinds: one with five petals, one with six petals and others with seven petals.

(b) There are two kinds of doubles different from the parent: one with two sets of petals and one with four sets.

2. It is assumed that multiplicity of corolla is a Mendelian unit character.

3. Among the seedling progeny there are fertile and self-sterile rosal plants. Expressed in Mendelian terms, three factors are concerned in fertility of rosal.

Pedigree cultures of the different seedling types are being carried on. These tests will show further evidence as to the definite inheritance of doubleness and singleness in *Gardenia florida*.

ILLUSTRATIONS

PLATE I

- Figure 1. Flower of the parent.
- Figure 2. Side view of the flower of plant 53.
- Figure 3. Side view of the flower of plant 30.
- Figure 4. Flower of plant 40.
- Figure 5. Flower of plant 53.
- Figure 6. Flower of plant 8.
- Figure 7. Flower of plant 10.
- Figure 8. Flower of plant 20.
- Figure 9. Flower of plant 14.
- Figure 10. Flower of plant 12.
- Figure 11. Flower of plant 26.
- Figure 12. Flower of plant 17.

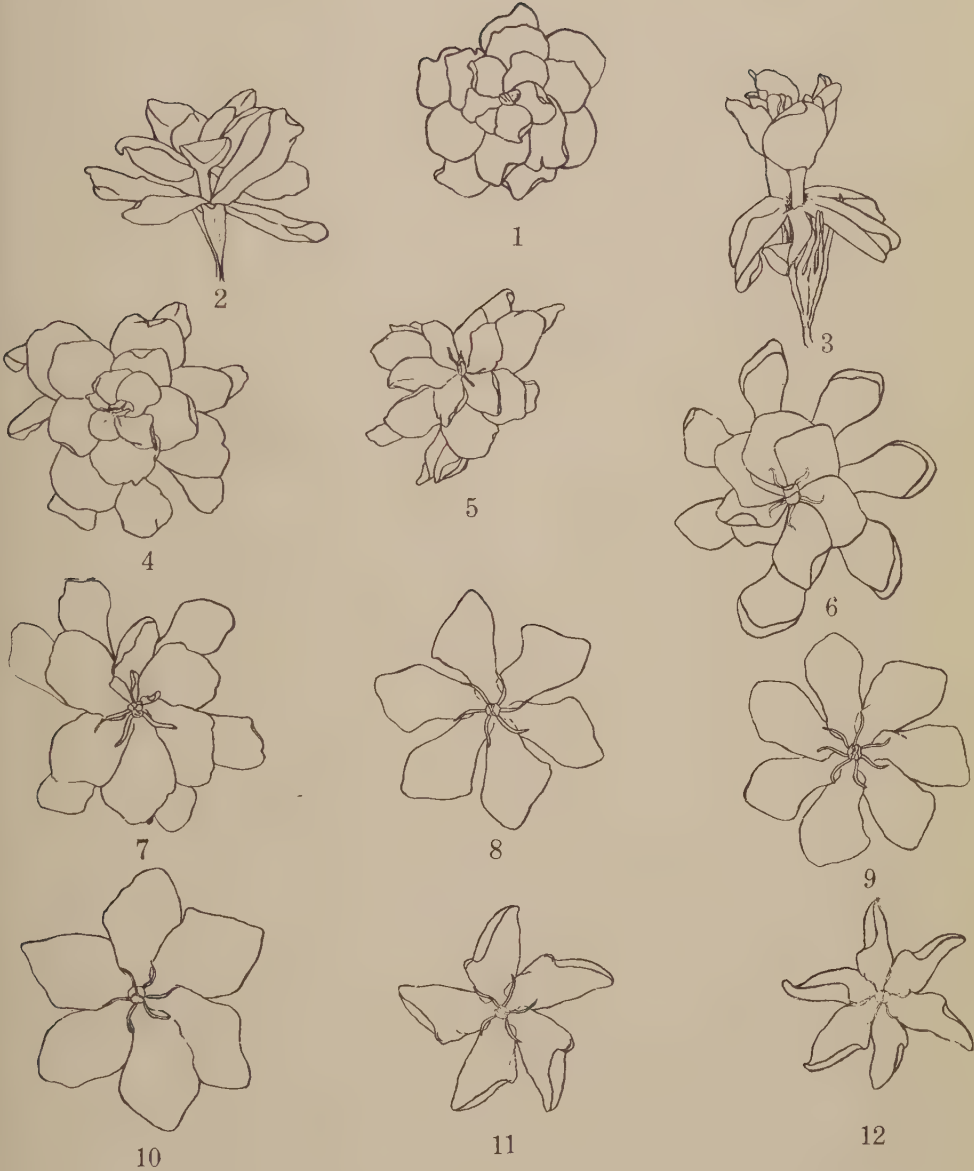


PLATE I

NOTE: DEAN BAKER AT SILLIMAN INSTITUTE

The College of Agriculture can feel that it rendered a valuable service by its Dean accepting the invitation to deliver the commencement address at Silliman Institute this year. The one address was multiplied by five. "A light that is set on a hill cannot be hid". On arrival at Dumaguete, Dean Baker was laid hold of days before Commencement. Doctor Chapman, Head of the Biology Department of Silliman, was desirous that his boys in science should hear Doctor Baker, so he assembled them in the lecture room in the Science Building where the Dean spoke to a large audience on agriculture on Monday morning. One of the teachers of the Provincial High School happened to be present and asked Doctor Chapman if he could not prevail upon the Dean to come out to the High School, about a kilometer from the College, and speak to his science students at 7:30 the next morning! How could Dean Baker turn down such a request? He didn't.

On the same day, Tuesday, was the Alumni Luncheon in Oriental Hall, the beautiful dormitory for the young women coming from a distance to study at Silliman. Of course there was no escape for the Dean here, and his toast on "the Palace of the Soul" was an impressive analogy carrying a message not soon forgotten.

Wednesday was Commencement, when Dean Baker gave one of his characteristically strong, clear, instructive and inspiring addresses on "Taking Courses in the School of Life". For forty-five minutes he had the entire audience leaning forward in wrapt attention. Students and faculty alike were enthusiastic in their appreciation of the address, referring to it as one of the best ever delivered at Silliman, and Silliman is in the habit of securing the best Commencement speakers available.

Eight years ago Doctor Baker visited Oriental Negros at the invitation of the owners of the Polo Coconut Plantation, situated about twenty kilometers north of Dumaguete. They were having trouble in getting the proper yield of fruit and wished advice. Doctor Baker looked over the situation, indicated the trouble and suggested remedies. The plantation owners were grateful and offered him a large fee as an expression of their appreciation. But Doctor Baker stated that his services were to the government and to the people, and declined any remuneration. One of the directors of the company a little later, writing to a friend, said, "That man Baker from Los Baños is about the craziest man I have ever met; don't know enough to take what's coming to him". When Mr. Dietrich, the manager of the plantation, learned that his helpful friend of eight years ago was again in Dumaguete, he insisted that Doctor Baker make another visit to Polo. So on Wednesday afternoon Mr. Dietrich took the Dean out to Polo where he remained until Thursday evening, visiting the plantation and noting the results of the proper use of the advice given eight years before. This plantation is in a distinctly unfavorable location for coconuts and its fine success is a striking illustration of what the Dean is always insisting on; namely, that the climate and soil and other considerations are the least to be thought of in connection with agriculture—the man's the key to the situation, and where there's a man who knows how to make use of methods and opportunities, he will wring success from the poorest soil and the most unlikely climatic conditions. This is Dean Baker's gospel to the young men preparing for agriculture in the Philippines.

The Dean thought he was through with speech making when he boarded the boat at Dumaguete and headed for Manila. But when he reached Cebu, he was captured by another group of friends and had to capitulate and give another address on Monday, March 16.

Dean Baker was emphatic in his praise of the evident good work being done in Silliman and of the spirit which pervades the institution. He declares that the lavish hospitality of the friends in the south is good for the heart, but it demands a stomach of large capacity.

CHARLES W. HAMILTON,
Pastor, Protestant College Chapel.

NOTE: LOS BAÑOS BIOLOGICAL CLUB

The Los Baños Biological Club closed its second year of existence with its ninth scientific meeting on February 26, 1925, at which Professor A. L. Teodoro read a paper "On the Important Features of the Common Types of Native Philippine Plows". Mr. T. P. Reyes presented a paper on the "Change of Sex Expression in Papayas as a Result of Mutilation."

Following the program was the election of officers and upon recommendation of the committee on nomination, Dr. Nemesio B. Mendiola was elected President, and Dr. Miguel Manresa, Secretary for the ensuing year, 1925-1926.

The retiring President, Dr. B. M. Gonzales reported on the progress of the club's activities during the term 1924-1925 as follows:

Object. The avowed object of the club is the promotion of research among the different faculties of the University of the Philippines established at Los Baños by providing a common meeting ground where members may discuss their lines of work and receive inspiration from their colleagues.

Accomplishment. It is gratifying to state that during the year and three months of existence of the club it has accomplished its purpose in a manner quite beyond the expectation of its original promoters. There is little doubt that it is stimulating greater activity on the part of those already engaged in research, and it is believed that it is having the same salutary effect on others.

Since its foundation nine meetings have been held, and altogether twenty-eight papers and reports have been presented, classifiable as follows:

Agricultural Engineering.....	1
Agronomy.....	5
Animal Husbandry.....	4
Botany.....	4
Chemistry.....	2
Entomology.....	2
Forestry.....	1
Plant Pathology.....	4
Veterinary Science.....	5

There has been a noticeable gradual improvement in the quality of the papers presented and in the discussions that followed them. If the members will continue their enthusiastic co-operation with the officers of the club, better records of accomplishment may be achieved.

Your retiring president is vain enough to believe that the Los Baños Biological Club will in time write a glorious name in the scientific world of the Far East.

EXCHANGE NOTES

There are still many who believe that a farmer needs no more than a grammar school education. But progressive farmers are coming to realize more fully than ever, that with the growing complexity of modern farming and the competition of other industries, one's chances of success are greatly improved by a thorough education. Surveys have shown that farmers with a high school education on the average have better incomes than those who never went to high school, and that college graduates are making still more money.

While this alone may be sufficient reason for continuing one's education, it is of less importance than other values which the right kind of an education provides. We refer to the development of personality that comes with the broadening of vision, the extending of experience, the multiplying of personal associations, and the discipline of study. Not mere knowledge, but the ability to meet and mingle with others on a basis of equality, is one of the accomplishments of the educated man

It is well to consider, then, not only the money returns of an education, but the opportunities for greater service, for developing a personality that will count for more in the world—in short, a training for leadership.

—*New Jersey Agriculture*, (State University of N. J.).

Before one can understand or appreciate the nature of the task set before the Locust Administration in its endeavours to combat locusts in the Bechuanaland Protectorate, one must attempt to visualize the country as it is . . . Its area is estimated at 275,000 square miles, all of which is sandy and lacking in water The population, evenly spread over the whole, would leave one individual to every two square miles

The successful co-operation of the leading native chiefs was ultimately secured and various bases fixed upon as poison depôts. But many difficulties arose in getting poison where it was wanted. There are no transport-riders, and unusual arrangements had to be made to meet the case. To several depôts poison was transported from three to five hundred miles, all the way through sand. . . . In some cases it took our officers over three weeks to reach their destination. . . . In such a country men live in fear of losing their bearings as well as their transport. To the fear of thirst is added the danger from wild animals. In the desert a coloured man became detached from the locust gang; some weeks later his bones were found; he had got lost and died of thirst. A camel officer knows that if anything goes wrong there is the certainty of an agonizing death. . . .

In some parts transport difficulties were so great that it was quite impossible to get poison supplies, so trenches were dug and closed up as they filled with voetganggers. In other parts of the desert to which it was possible to transport poison, only the powder could be used on account of the lack of water.

The most difficult portion, also practically uninhabited and waterless, was worked by camel officers, while others with pack-oxen worked in other areas. In some cases locust officers went more than two months without being able to spare water to cleanse their person and clothes. In other parts the only water available is practically undrinkable, and several officers became ill.

As a result of the first campaign in Bechuanaland Protectorate in 1922-23, 24,204 swarms of voetgangers were destroyed, and during the 1923-24 campaign 42,777 swarms. The locusts not having been previously disturbed in their laying operations, the swarms were of exceptional dimensions.

—*Journal of the Department of Agriculture* (Union of South Africa).

An idea of the importance of coconuts and rice (in Malaya) compared with rubber may be obtained from the following table, which is an estimate of the area planted in 1920 in British Malaya:—

Rubber.....	2,000,000 acres
Padi (rice).....	600,000 “
Coconuts.....	400,000 “

Of the above, the area under padi is entirely in the hands of the natives, while that under coconuts was being cultivated to the extent of one-third under estate conditions, the remaining two-thirds being held by small owners. . . .

—*Tropical Life*.

Despite keen competition, American manufacturers are exporting increasing quantities of rubber heels. There were 1,249,661 pounds valued at \$400,311, exported from the United States during the first six months of 1924. Sixty per cent of the exports went to Mexico, the Philippine Islands, and Cuba.

—*Commerce Reports*, (U. S. A.).

Name your farm. A good name adds something to it both as a home and as a place of business.

—*California Cultivator*.

At the present time approximately 5,000 acres of oil palm have been planted in Malay areas of which some 1000 acres are in bearing. From the results obtained both in Malaya and Sumatra, where the palm is now cultivated on a large scale, it may be stated with some degree of assurance that returns from this crop are sufficiently promising to warrant the planting of further areas, provided suitable land is available.

Further, the report goes on to say, on account of the large amount of machinery required, the African oil palm is a crop which must be cultivated on a fairly large scale, preferably not less than 1,000 acres, unless it is possible for one or more adjoining estates to combine in the erection of a central factory.

—*Tropical Life*.

COLLEGE AND ALUMNI NOTES

Dean Baker was the principal speaker at the Provincial High School Commencement exercises at Santa Cruz, Laguna.

Dr. Otto A. Reinking, formerly Professor and Head of the Department of Plant Pathology of the College of Agriculture, University of the Philippines, and now pathologist to the United Fruit Company, stationed in Tela, Honduras, arrived in Manila on the S. S. *President Wilson*, March 23, 1925. Doctor Reinking is collecting Philippine, Indo-Malaysian, and African varieties of bananas which can be introduced into Central America.

The Department of Plant Pathology wishes to thank Doctor Reinking for valuable information and suggestions in connection with the banana wilt problem in the Philippines.

Dr. C. E. Pemberton, assistant entomologist of the Hawaiian Sugar Planters' Association, is at present in the Philippines, with headquarters at the College of Agriculture, for the purpose of collecting parasites of the mole cricket, *Gryllotalpa africana* Beauv., and introducing them in Hawaii. Insects attacking various species of *Cyperus* and other noxious weeds of Hawaiian fields are also being studied with the end in view of colonizing them in that country.

Dr. E. Mjorberg, Swedish scientist who has been working for the past few years under the British Government in Sarawak, the "Land of the White Rajahs," was a guest of Dean Baker, an old friend, for a few days in February. In a letter to the Dean, written just before sailing from Manila, Doctor Mjorberg says: "I admire greatly the splendid and unselfish work you have done for years. Only a true scientific enthusiasm can achieve such triumphs."

Prof. Evett D. Hester, Head and organizer of the Department of Rural Economics and Registrar since 1922, and formerly editor of THE PHILIPPINE AGRICULTURIST, after six years' service in the College, resigned at the close of College year, 1925.

"What shall we do without Hester?" was a frequently heard query after his resignation was announced. To enumerate the ways in which Mr. Hester served the College would indicate a general utility man, while, instead, he is a versatile man with "getting things done" one of his characteristics. But his three notable achievements which will stand as his testimonials are the Rural Economics Department, the well organized, smoothly running Registrar's Office and the Library which was evolved from an inchoate nucleus. It is not his work alone for which he is esteemed but also for himself, always pleasantly willing as well as competent.

Both faculty and students expressed in various ways the high regard in which they hold Professor Hester. One expression was in form of a handsome silver cigarette case from Faculty Hill residents presented to him at a *despedida* gathering at the home of Doctor Gonzales.

The Department of English suffers a real loss in the resignation of Prof. E. Gertrude Madison. Not only this department but the College, for in the two years Miss Madison has been with us, she has created a position of great usefulness through her valuable and untiring service in conducting College singing, and rehearsing and directing and in some cases writing plays, In helping with special programs, rooting at ball games, in fact in all lines of activities that make for a fuller, better life among students her absence will be deeply felt.

Appreciation of Professor Madison's work and of her personality was expressed by several *despedidas* by the students. One farewell gift, a Filipino woman's costume, will be shared with pleasure by Miss Madison's homeland friends. The Faculty expressed their appreciation of Miss Madison in various farewell affairs.

The Class of '25, numbered fifty-nine. For the first time in the history of the College medals were awarded as marks of distinction for outstanding achievement.

The Joaquin J. Gonzalez Medal, to be awarded annually by Mr. Joaquin Gonzalez '19, is for highest scholarship. This is the first gift from an alumnus of this College to his Alma Mater, and we understand in the U. P. This beautiful gold medal which has Minerva's bird as the principal part of the design was awarded this year to Paul Sindhuravejña from Bangkok, Siam. Francisco Sacay and Leopoldo Villanueva both "with honors" were only a fraction below the medalist. The Faculty Medal given this year for the first time is awarded not annually, but when there is a graduate outstanding in scholarship, college activities, qualities of leadership, character, integrity and promise of making a good citizen. It was awarded to Gonzalo Salazar.

Those receiving Master's degrees were: José B. Juliano, in Botany; Teodoro P. Reyes, in Agronomy; Juan O. Unite in Agronomy; and Eligio C. Ureta in Chemistry.

The Department of Rural Economics will be in charge of Assistant Professor Mariano C. Lopez. Mr. Lopez will also be Acting Registrar. Professor Lopez studied in the University of Pennsylvania and Georgetown University. He also took graduate studies in the Graduate School of Political Sciences, American University, Washington, D. C.

Miss Dorothy C. Hall, instructor in English, resigned at end of College year. Miss Hall sailed for the United States on March 15.

Preparation of Scientific and Technical papers by Trelease and Yule is in print. It is a neat handy little book. As it was published by Williams & Wilkins Company, the best authority in America in technical publications, the book, itself, is a model in form and style.

Dr. M. L. Roxas and Prof. H. Henares of the Chemistry Department, have been requested by a private company to install an experimental mill in Borneo for the manufacture of sugar from nipa sap. Mr. Getulio Guanzon, '25 in the Sugar Technology Course, will accompany them as assistant.

Dr. Robert L. Pendleton of Soils Division with headquarters at Silay, Occidental Negros, was engaged for several weeks in making soil surveys of several sugar cane plantations on Negros during summer vacation. He made a brief visit to Panay on similar work and spent some time in soil survey work on the island of Mindoro.

Doctor Fronda of the Department of Animal Husbandry made an official visit to the towns of Binangonan and Pateros, Rizal, in March. Binangonan has long been famous for its turkey industry, while Pateros is very well known both locally and abroad for its ducks. In Pateros, several of the larger native hatcheries, the *balutan*, were visited. Doctor Fronda was accompanied by Moises Villaluz, the College artist.

Dr. Nemesio B. Mendiola spent the summer vacation in Zamboanga. He was so interested at San Ramon Penal Farm in the plan of training the roosters to care for the chicks that he wrote Doctor Gonzales about it. But our Poultry Division was not caught lagging as Doctor Fronda has one rooster taking care of 100 chicks. The training of capons for this erstwhile hen-duty is an old story with Doctor Fronda. But the department appreciated Doctor Mendiola's interest.

Florentino Cruz, B. Agr. '16, M. F. '23, wrote some weeks ago that he had sold 54 steers from his private ranch at ₱115 per head and that he has 100 more about ready for sale. He also wrote that on the Nellore Ranch of which he has charge, the cattle have increased from 394 in 1921 to 1630 in 1924. There is hardly any other agricultural line that can show such increases in assets in so short a time. Mr. Cruz wants good men to work under him and promises them first class opportunity to work up in the stock business.

At the request of Mr. Vicente J. Llamas, Jr., proprietor and manager of a newly established poultry farm in Pagsanjan, Laguna, Doctor Fronda, accompanied by Extension Director Elayda, visited his farm in April. Mr. Llamas is a U. P. graduate, 1924, and took several courses in the Department of Animal Husbandry in this College to complete his elective requirements in Commerce. He has recently come back from a five months tour in the United States. While there, he visited Petaluma, famed for its poultry industry, and a number of the well known poultry farms on the Pacific Coast, and also the famous duck farms on Long Island.

Professor Alincastre is taking advantage of his accrued leave by working as chemist for the Isabela Sugar Central's Milling Company.

For the first time in the history of the College, a course for the benefit of mature people desiring special training along some practical agricultural line was given this past vacation. The course given was on poultry raising by the Department of Animal Husbandry.

The enrollment for the Summer School was 299.

The Band Stand, the joint gift of Class of '24, the Faculty, Student Body, and Rizal Center, was formally presented to the College of Agriculture on January 10. The presentation was made by Professor R. B. Espino, Adviser of Class '24. Dean Baker in a brief address accepted the gift for the College.

Addresses were made by Mr. Delfin Divinagracia, President of the Student Body, and by Dr. M. Manresa of the College of Veterinary Science, Noble Secretary of the Rizal Center. The College Orchestra furnished the music. The Band stand is located between the tennis courts and the baseball diamond.

The following extract from the *New York Times* January 6, 1925, tells of another step up the ladder of life by Dr. Sam F. Trelease formerly of our Botany Department. Because of general interest we quote also the plan of work as suggested in the article.

The Trustees of Columbia University announced yesterday that Dr. Sam F. Trelease had been appointed Associate Professor of Botany at Columbia and placed in charge of extensive researches which are to be carried out in connection with the New York Botanical Garden into causes of plant diseases, the effect of air pollution in American cities on plants, the effect of the automobile on vegetation and many similar subjects.

The Board of Managers of the New York Botanical Garden are seeking an increase of endowment of \$7,000,000 in order to develop plans for increasing the usefulness of the Garden. Dr. Trelease is now Professor of Plant Physiology at the University of Louisville. He was formerly a member of the faculty of the University of the Philippines.

The program of scientific research planned at the New York Botanical Garden is a sweeping departure from methods which have been pursued for the last thirty years, according to a statement issued by Dr. Frederic S. Lee, President of the Board of Managers of the Garden and research professor of biology at Columbia.

"Up to the present," he said, "the Garden's scientific researches have been confined chiefly to the field of systematic botany and less attention has been given to other fields of the vast science of plants.

"But the problems in these other fields are so timely, so promising and so immediately connected with the welfare of mankind that their solution should now be undertaken as additional contributions to knowledge. These problems have to do with the plant as a living organism—with its normal, healthy life-processes, its disease-processes and its processes of inheritance and the production of new and often better types.

"There are, moreover, many fundamental problems of disease processes in living beings that can probably be studied more readily in plants than in animals or men. For all these problems here mentioned, and hosts of others that might be mentioned, the Garden possesses unusual facilities in its site and its large vegetation.

"They are problems that require the use of the experimental method, the method which more than any other has been instrumental in the phenomenal advance of science that has characterized recent years."

Mr. Teodorico P. Reyes, M. S. '25, Assistant in Agronomy Department, sailed on *President Cleveland* April 21, for Honolulu. Mr. Reyes will be in the employ of California Packing Corporation in Honolulu. His work will be the conducting of some experiments with pineapples. He was granted leave of absence without pay from this College that he might have this opportunity for work abroad.

Mr. Eligio Ureta, graduate assistant in Chemistry, has resigned. Mr. Ureta while working as assistant specialized in soils and obtained the degree of Master of Science in Agricultural Chemistry this year. He expects to go out and practice.

Mr. Paterno V. Bayan of the Class of 1925 of the College of Agriculture has been appointed assistant in Animal Husbandry, effective April 1, 1925.

One hundred members of the Senior Class of the Central Luzon Agricultural School visited the College of Agriculture on February 13 and 14. Accompanied by their Class adviser, Mr. Pedro Montellano '15 and four other teachers, they came in three auto-trucks. The Student Body of the College of Agriculture entertained the Muñoz seniors with a musical program in the evening of the 13th, at which Dr. F. Fronda gave an illustrated lecture on raising poultry for profit and Prof. E. D. Hester explained the relation of the curriculum of the College of Agriculture and that of the Muñoz Agricultural School. The Muñoz students spent the forenoon of the 14th visiting the various departmental laboratories. The visit was closed by an enlightening talk by Dean Baker.

Mr. Sabino Ami, formerly a student of the College of Agriculture, accompanied by his wife, visited the College of Agriculture February 17 to 19. He conferred with various members of the College staff. Mr. Ami is the principal of the Bukidnon Agricultural School. He was the creator of Ami's bean, the standard soy bean of the College.

An exceptionally well presented program was given by the Student Body on Washington's Birthday.

Mr. Delfin Divinagracia's address on Washington, as an agriculturist, was replete in thought, well expressed and well delivered. Doctor Pañganiban, recently returned from three years study in the United States, entertained the audience with some of his interesting and amusing experiences in America. A pantomime, "The Way to Freedom," showing how improved methods of farming will drive away the usurer, disease, and debt was a vivid wordless lecture. It was arranged and directed by Prof. E. Gertrude Madison.

The second part of the program was the presentation, under the direction of Professor Madison of the drama "Daughters for Sale" by Carlos Romulo. The cast was:

Don Pelagio, a sabuñgero.....	Agapito Muyargas
Gregorio, the barber.....	Marcelo Arnaldo
Rosario, school teacher.....	Dolores de Jesus
Maria, engaged in social welfare work.....	Pilar Carrera
Amparo, U. P. graduate.....	Irene P. Mariano
Don Juan, prosperous land owner.....	Eligio Tavanlar
Aurelio, Commerce graduate.....	Jacinto Leoncio
Mariano Dy Joco, Chinese Merchant.....	Pedro Paje
Miguel, College of Agriculture graduate.....	Filemón Español

Music for the evening was by the College Orchestra.

Bugle calls, shouts, and laughter of camping youngsters gave the students' residence portion of the Campus a lively air during the summer vacation. The campers were all under the auspices of the Y. M. C. A. There were four groups: "Hi-Y" from Manila High Schools; Chinese "Y" Boy Scouts; junior members of Manila Y. M. C. A. formed the third and fourth groups; in all about 300.

A reprint of an article in *The London Times*, an appeal for funds for additional laboratories for the new Imperial College of Tropical Agriculture in Trinidad, West Indies, was recently received. As one of our valued exchanges *Tropical Agriculture* is published by this College and in age, latitude, and object, we are similar, our interest in this sister institution is more than casual. To quote from article:

"The Imperial College is not an institution of merely local importance. It is intended to serve all our tropical possessions and is started in lines which, given adequate support, will enable it to carry out this comprehensive scheme. * * * For the progress of tropical Colonies the fight against diseases of plants is no less important than that against human disease, and in the one case as in the other, the battle can only be won by the weapons of science. * * *

In the United States, as is well known, enormous sums have been devoted and wisely devoted to the teaching of agriculture including tropical agriculture.